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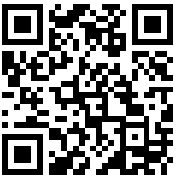

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THE INTRODUCTION OF MECHANICAL WARFARE ON LAND AND ITS POSSIBILITIES IN THE NEAR FUTURE

A Lecture delivered at the S.M.E., Chatham, 11th November, 1920, by COL. J. F. C. FULLER, D.S.O.

Opposition to the Coach.—In 1565 it is recorded that the first coach constructed in England was built for the Earl of Rutland, but on account of the execrable condition of the roads of this period and the dangers of the highways, it was not until 1669 that systematic journeys were attempted in England and then only between Oxford and London.

Coaching was a novelty and, like every rational and profitable novelty, before or since, its progress met with strong opposition. Early in the seventeenth century a Bill was brought before Parliament in order "to prevent the effeminacy of men riding in coaches"; and in 1671, Sir Henry Herbert, M.P., stated that—"if a man were to propose to convey us regularly to Edinburgh in coaches in seven days, and bring us back in seven more, should we not vote him to Bedlam." Nevertheless the coach for its period had come to stay, and on October 13, 1712, a weekly service was instituted between London and Edinburgh. The journey was made in thirteen days and the fare was £4 10s.

Opposition to the Locomotive.—In 1641, that is twenty eight years before the first coaching service was instituted in England, the Marquis of Worcester, famous as the inventor of an early steam engine, went to see Solomon de Caus in the Bicetre at Paris. Marion de Lorme who was with him when he visited this madhouse, wrote as follows:—

"We were crossing the court, and I, more dead than alive with fright, kept close to my companion's side, when a frightful face appeared behind some immense bars, and a hoarse voice exclaimed—'I am not mad! I am not mad! I have made a discovery that would enrich the country that adopted it.' 'What has he discovered?' asked our guide. 'Oh!' answered the keeper, shrugging his shoulders, 'something trifling enough; you would never guess it; it is the use of the steam of boiling water.'" Why was Solomon de Caus there? To keep his brain from mischief; he had actually suggested that carriages and ships could be propelled by steam!

In 1769, James Watt invented the first practical steam engine. He also was considered mad, but fortunately for posterity he was not locked up. In 1804 a locomotive guided by rails attained the

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speed of five miles an hour at Merthyr Tydvil and ten years later George Stephenson, financed by Lord Ravensworth, to whom was applied the adage—"A fool and his money are soon parted," began work on the Killingworth Railway. He met with immediate obstruction, Lord Eldon saying, "I am sorry to find the intelligent people of the North country gone mad on the subject of railways."

Stephenson was undaunted and before the Stockton and Darlington line was completed, in 1821, he said to his pupils—"Now lads, I venture to tell you that I think you will live to see the day when railways will supersede almost all other methods of conveyance in this country—when mail-coaches will go by railway, and railroads will become great highways for the King and all his subjects. The time is coming when it will be cheaper for a working man to travel on a railroad than to walk on foot."

To this the *Quarterly Review* incredulously exclaimed—"What can be more palpably absurd and ridiculous than the prospect held out of locomotives travelling TWICE AS FAST as stage coaches! We should as soon expect the people of Woolwich to suffer themselves to be fired off upon one of Congreve's ricochet rockets, as trust themselves to the mercy of such a machine going at such a rate. We will back old Father Thames against the Woolwich Railway for any sum. We trust that Parliament will, in all railways it may sanction, limit the speed to EIGHT or NINE MILES AN HOUR, which we entirely agree with Mr. Sylvester is as great as can be ventured on with safety."

Once the locomotive began to crawl, the sluice gates of abuse were opened, and its inventor met with obstruction at every turn. A meeting of Manchester ministers denounced the railway as being 'contrary' to the law of God. Lord Derby drove the railway surveyors off his land and Stephenson had to hire a prize-fighter to carry his theodolite in order to prevent it being smashed to pieces. Pamphlets were written and newspapers hired to revile his work. It was declared that the railway would prevent cows grazing, hens laying, and would cause ladies to give premature birth to children at "sight of these things going forward at the rate of four and a half miles an hour."

Parliament supported the reactionaries; birds would be killed by the smoke, foxes would become extinct, horses would be useless and oats and hay unsaleable; country inns would be ruined, boilers would burst and blow passengers sky high, and finally, the weight of the locomotive would prevent it moving.

Nevertheless Stephenson persisted and was besought by William Brougham not to talk too much about speed before the Parliamentary Committee which was to enquire into the question, or else he would "inevitably damn the whole thing and be himself regarded as a maniac fit for Bedlam."

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The Committee of the House of Commons assembled on March 21, 1825, and the opposing counsel addressed these words to the great inventor:—

"Suppose, now, one of these engines to be going along a railroad at the rate of nine or even ten miles an hour, and that a cow was to stray upon the line and get in the way of the engine; would not that, think you," asked the barrister, "be a very awkward circumstance?"

"Yes," replied George Stephenson, with his face in a humorous pucker, "very awkward indeed—*for the coo*!"

Opposition to the Tank.—Why have I told you all this? Simply in order to avoid relating to you the studied opposition which was meted out to the tank. It is right and necessary that you should realize this, for on your support, in future years, will depend the progress of mechanical warfare, which is the subject of my lecture.

In 1914 was the tank conceived; in 1915 was it built; in 1916 was it first made use of; in 1917 did it fight for its existence, and in 1918, I go so far as to say, that without its assistance we should not that year have won the war. In 1919, an experimental machine attained a speed of 20 miles an hour; and now in 1920, is it still struggling against difficulties, for prejudice to things new dies hard and vested interest is a powerful adversary.

Whatever the tank has accomplished, it is still far from perfect, it is still in the Puffing Billy stage of 1822; Puffing Billy which George Stephenson was wont to drive close by his brother's house and concerning which, when it stuck fast at a curve, he would shout out to his wife—"Hey! Jean, come oot, and gie us a shove round the turn!" Twenty years later we read—"A few years since ninety-four coaches used to pass through St. Albans daily. On Saturday last the Leeds Express, formerly called the 'Sleepy Leeds,' which has been on the road upwards of a hundred years, ceased running, it being no longer a profitable speculation."

The coach was dead, the railway had come into its own, a new and stupendous world was born, and through mechanicalizing civi movement, by replacing the horse by the steam engine, civilization has advanced more rapidly during the last eighty years than she had advanced during the preceding eight thousand.

Here then is the gist of my lecture. What the locomotive has done for civilization will the internal combustion engine do for war. It opens up before us a new world of warfare stupendous in its possibilities. Let us enquire into it, and do not let us fall into a frenzy because possibly rifles and swords, bayonets and lances, horses and limbers may disappear, for even if they do, we may be perfectly sure that things more efficient will replace them.

Opposition to the Rifle.—I will now turn for a few minutes to what I will call the coaching period in the history of the war, chiefly in

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order to obtain a background whereon to throw into relief the future tendencies of mechanical warfare.

In the 15th century gunpowder was considered useful for frightening horses, a century long argument then followed, concerning the bow and the musket, and as many arguments were launched for the retention of the bow as to-day are quoted for the retention of the lance. The bow has, however, vanished, but not without a struggle, for as late as 1797 a certain Mr. Mason once again proposed to equip British infantry with it.

In 1742, Benjamin Robins in his "New Principles of Gunnery," made a remarkable prophecy as to the eventual adoption of the rifle, which, however, did not take place until a hundred years after his day; he says:—

"..... whatever State shall thoroughly comprehend the nature and advantage of rifled barrel pieces, and having facilitated and completed their construction, shall introduce into their armies their general use, with a dexterity in the management of them, will by this means acquire a superiority which will almost equal anything that has been done at any time by the particular excellence of any one kind of arms, and will perhaps fall but little short of the wonderful effect which historians relate to have been formerly produced by the first invention of firearms."

In 1780, Major Patrick Ferguson invented a breech loading rifle. He paid for its manufacture out of his own pocket and equipped his men with it so that they might meet, on equal terms, the American backwoodsmen. He then, unfortunately, went sick and Lord Cornwallis the Commander in Chief had the rifles withdrawn and destroyed.

In 1824 the British Government refused to accept Captain Norton's cylindro-conoidal bullet. It was reproduced by Captain Minié of the French Army in 1849. The Minié rifle became the weapon of the day, nevertheless, Sir William Napier strenuously opposed it, as in his opinion, it would destroy the infantry spirit by turning infantry into what he called "long range assassins."

In 1858, Greener declared the "time and ingenuity spent in planning and constructing breech-loading cannon will always end in disappointment and failure" and again, that "striving to produce perfect breech-loading cannon is like striving to square the circle." Consequently the British Army did not permanently receive such a weapon until 1886. Even as late as 1895, when the *Victoria* went down with Admiral Tryon, some of her guns were still muzzle-loaders.

In spite of opposition, the breech-loading rifle and field gun—which I will call the "military coach," for both depended on muscular movement—came into their own.

Phantom Wars.—In August, 1914, the finest muscularly organized body of troops ever raised by Great Britain left her shores. I was

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fortunate enough to see them all, and I can frankly say that in all my life I have never, before or since, seen such a perfect force of men and horses as those of the 7th Division and the 1st Cavalry Division which sailed for Zeebrugge and Ostend. The Duke of Teck himself told me that he had not a horse in his regiment under the value of 200 guineas. A fortnight later the 7th Division had almost ceased to exist. What had happened?

Many things, amongst which was one, to my mind the most important, which for long remained obscure. The war we had prepared for was a phantom, a will o' the wisp which literally led us off the highway of progress into a "slough of despond."

What had we failed to realize? We had not realized this—that an Army to prosper must be based on the civil sciences, that an Army must keep pace with the progress of industry and that an Army which does not do so is but a phantom force for war.

Irresistible Science.—Since 1842 when the "Sleepy Leeds" had run her last journey on the great north road, what had been happening in civil life? A mechanical evolution so rapid that no revolution in the whole world's history can compare to it. Every day brought to birth some new invention, every hour civilization gathered greater speed; epochs crumbled away, epochs sprang up in the night, science was sweeping brute force off the face of the earth, and was replacing muscle by mechanical energy.

In 1885, Gottlieb-Daimler designed the first practical internal combustion motor. In 1896 the first motor car in England ran from London to Cambridge preceded by a man carrying a red flag. Parliamentary opposition was revived, humanity could not live with the road car, the roads would become unsafe, children would be run over, dogs and fowls exterminated, and carts overturned. The country gentleman got his back up, but the Rolls-Royce soon got it down.

In 1770, the first patent for a footed wheel was registered; in 1888, an agricultural tractor, almost identical to the future tank, was designed; in 1907, a motor car on tracks attained the speed of 20 miles the hour on firm sand. In 1909, at the first flying meeting held at Rheims, General Grierson, an able soldier, watching an aeroplane, turned to General Stone and said—"I say, Stone, do you really think there is anything in it?" and General Stone's comment on this remark is worth recording—"That is only ten years ago, and it is a very striking fact that such a very short time ago as that some of the best brains in the Army (because I could mention other names, but I do not think it would be wise to do so) thought that anybody who took up flying seriously was a little bit 'gone in the head.' I speak of what I know."

It is indeed easy to be wise after the event, but surely it is better to be thus wise than never to be wise at all. In 1914, the armies of

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Europe marched forth to fight Worth, Gravelotte, and Sedan over again, forty-four years of scientific progress had been neglected, and the bill—10,000,000 men killed and over £60,000,000,000 expended. In 1918, the war was costing Great Britain £300,000 an hour, or the present price of the yearly upkeep of two infantry battalions. Gentlemen, science is worth studying.

The Nature of the Great War.—Let us turn for a few minutes to the nature of the Great War. One of its most remarkable features was that it resembled the battle of Marathon (B.C. 490), for the greater portion of its duration the battle had no flanks. Why? Because the enormous size of armies enabled battle fronts of upwards of 500 miles to be held in strength, entrenched and wired. What had rendered this possible? The locomotive, the railway, and the steamship, the great mechanical movers of civil life. Soldiers had not considered them very deeply, then, when war was declared, they like great funnels poured forth men in cataracts. Immense tracts of country were inundated and for over three years, on the Western Front, armies lay opposite each other in stagnating puddles and slowly evaporated away.

We see a strange sight: millions of men facing each other, millions of men the subsistence of which, prior to battle, depended on every yard of rail and road behind them being utilised to the full. Lorries and locomotives worked day and night to supply this enormous muscular mass, to pile up the military coaches which, from time to time, were launched from their mechanical base into battle areas devoid of railways and all but devoid of roads. What do we then see?—We see strings of pack mules and thousands of human carriers wallowing through the mud; in a single day the administrative needs of the Army have increased tenfold and the means of supplying these needs has retrogressed by several thousand years. This brings us to our first main problem in mechanical warfare, the problem of road capacity.

Road capacity.—In August, 1915, a meter gauge railway ran from Gezaincourt to Albert and I suggested to an officer, quite an able man, that if a certain British Corps made use of it considerable economies could be effected. His answer was—"It can't be done for if we use this railway we shall disorganize the whole of our lorry service!"

In the eighteenth century, the squire who brought his wife to London sitting behind him on his cob, objected to the stage coach. In the nineteenth century he had accepted the stage coach and objected to the locomotive. In the twentieth, he accepted the locomotive and fell foul of the motor car. And so in 1915, we find an able officer objecting to the light railway. Why? Because of what I will call congenital prejudice, which can only see the means and not the end, and which having made a hobby of the

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means refuses to see the end. I will give you a typical example of this.

In the first decade of this century, a meeting of the Directors of the London General Omnibus Company was held. A young engineer got up and suggested the replacement of horses by petrol engines; he pointed out that the shares of the Company stood at a very low figure and that he could raise them several hundred per cent. This so enraged one of the elderly Directors, who could only see the existing means—the horse—and not the end, a high dividend, that trembling with rage he exclaimed, "You may take it from me, Sir, that the horse will remain the backbone of this Company for many, many years to come." Within a few years of this prophetic outburst the horse in the L.G.O. had disappeared and the Company's shares stood at a price far higher than the young engineer had ever dreamt of.

In 1914, a few score of lorries formed the mechanical equipment of the British Army. In 1917, they had grown in number to about fifty thousand, hundreds of miles of new railways and thousands of miles of tramways covered the British fronts. For three years we had been fighting for road capacity, and behind our front line we had attained it, but in advance of it, it ceased to exist. Armies became like caged animals, they could move about in their own prisons at will and in perfect safety, but to escape from them was next to impossible.

I will take a few examples to illustrate this and will select them out of the events of the last year of the war, during which the bars of the cages had become somewhat more elastic:—

(1).—In March, 1918, the Germans gained against us an overwhelming success; they advanced some 40 miles in 14 days and were then forced to halt. To many who took part in this operation, it was apparent that it was not the British Army which caused this halt, but the weakness of the German Army due to the "Petering out" of its supply system. Road capacity in the Somme area was limited, want of road capacity, which might well have been foreseen, completely wrecked the last chance the Germans had of winning the war.

(2).—In May, 1918, the Germans gained another overwhelming victory, this time over the French, the result of which was an advance of 30 miles in 4 days, and the formation of the Chateau Thierry Salient. As long as Soissons remained under gun fire and Rheims held out, road capacity, from the railway point of view, was to all intents and purposes non-existent. To remain in this salient without road capacity was to commit suicide. This is exactly what the Germans did.

(3).—In August, 1918, we attacked eastwards of Amiens, behind us was an efficient railway system, in front of us good roads, which, during the battle, were never much damaged; nevertheless, our

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initial success, which was stupendous, rapidly " Petered out " after the first day's fighting. This was due to several reasons, one being the difficulty of maintaining the energy of the battle by supply, in other words " road capacity " was insufficient to enable us to continue the advance, and would have been more difficult still had we attempted to force our way across the old Somme battlefield.

The lesson to be learnt from all this fighting, and probably the most important lesson to be learnt from the whole war is " That the chances of victory or defeat are multiplied directly by any increase or decrease of road capacity in an area of operations, and that unless this road capacity be equal to the supply requirements of the attack, either the attackers must eventually die of starvation or the attack must be abandoned."

This problem may be viewed under two main headings :—

(1).—Means of cutting down the necessity of supply.

(2).—Means of increasing the transportation of supply.

I do not intend to discuss the first beyond saying that the quicker an army can move, the less supplies, in the long run, will it require. As regards the second, it may be viewed under four subsidiary head headings :—

(*a*).—Concentration of traffic.

(*b*).—Additional road space.

(*c*).—Additional roads.

(*d*).—Dispensing with roads.

The first is gained by increasing the tonnage per road mile. The second by constructing vehicles which will move alongside a road over plough and grass land. The third by making use of badly metalled roads or by building new ones. The fourth by cross-country traction which will enable all normal country, plough and grass land desert and scrub, to be crossed as easily as a lorry to-day will move along an average road.

Can such a machine be obtained ? It can !

The Administrative Link.—What will the cross-country lorry accomplish ? It will mechanically link up the strategical base of operation, which consists of a network of railways, with the battlefield itself. No longer will there occur that terrible hiatus between rail-heads and battle dumps. You won't dump, but you will move. As the battle starts so will it be continued, there will no longer be an exchange of supply horses in mid stream. Right through the Great War this problem remained all but unrealized, and only towards the end was any notice taken of it, and yet on its solution depended the dividend of every attack.

Often was the question asked,—What happens when a penetration has been effected ? The answer is " push up supplies," supplies of men, weapons, munitions, and food ; the side which can do this the most quickly is the side which is most likely to win. The problem

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is, consequently, not so much a tactical as an administrative one, and looking back it can now be seen that the General Staffs of all armies never fully realized this.

The Tactical Link.—Given a mechanical strategical base and a mechanical supply system, logically, the next link to forge is a mechanical tactical striking force. In other words, to cease hauling up to the front innumerable military coaches by means of mechanical power, as the old four decker sailing ships were towed into position opposite Sebastopol and towed away again after an engagement, but instead to replace the coach by a military motor car and so render the whole army from start to finish a mechanical one.

The necessity of this was realized early in the war by a few far-seeing men, and the result was the tank—a cross-country battery which, protected by armour, was enabled to make use of protected mobility for offensive ends.

The idea of protected mobility gave birth to much mirth; one noted officer requested Colonel Swinton to abandon his "flights of imagination and come down to solid facts;" another, when he was informed that his troops were to be led by tanks through the Cambrai wire, exclaimed "fantastic! fantastic!" The press correspondents filled the newspapers with "slimy monsters and Gargantuan toads," but what was worse, a passive and effective barrier of obstructions was raised against all efforts of the Tank Corps to expand.

A bad second to the obstructor was the amateur enthusiast, who, knowing nothing about tanks, expected them to perform miracles.

In 1829, George Stephenson was faced with the problem of running a railway over Chat Moss. Mr. Alderson obstructed and made a speech opposing it which lasted two days in the Commons. Mr. Cropper, a Quaker, urged Stephenson on. "Consider sir," said Stephenson, "the heavy character of the works, and how much we have been delayed by want of money, not to speak of the wet weather. It is impossible."

"Impossible," retorted Cropper, "I wish I could get Napoleon to thee—he would tell thee there is no such word as 'impossible' in the vocabulary."

"Tush!" said George Stephenson contemptuously; "don't talk to me about Napoleon! Give me men, money and materials and I will do what he couldn't do—drive a railroad from Liverpool to Manchester over Chat Moss!"

We, to-day, are faced with our Aldersons and our Croppers, but what we want is men, money, and materials and we will then do what neither Napoleon nor Stephenson could do; move men across country faster than the Rocket ran along her rails.

I do not intend here to describe to you what the tank accomplished during the Great War, for this you already know, or if you do not,

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then you ought to for its history is pregnant with the future ; neither am I going to plan for you a mechanical army, nor picture to you some imaginary Armageddon of 40 years hence. In place I am going to glance at our present military problem and point out to you how cross-country traction will help us to solve it.

Imperial Defence.—What is the present Imperial situation ? Lassitude after battle, a low exchequer in debt to the tune of nearly £10,000,000,000 and enormous territorial liabilities to safeguard by means of a navy and army which will eventually be no bigger than those of 1914.

If we cannot get more money we cannot get more troops ; if we cannot get more troops and those we have are insufficient to maintain the integrity of the Empire, what can we do ? We can do one of two things :—

(1).—We can abandon large tracts of country and so enable our securities to meet our liabilities, or

(2).—We can indirectly reduce the size of our territorial liabilities by endowing our securities with a power of moving over them more rapidly than they can at present.

Thus, if I can walk from Chatham to London, a distance of thirty-five miles, in twelve hours and you can motor to London in two hours, when reducing space to terms of time you will find that you have decreased the area to one-sixth of the size it appears to be to me. Now I suggest here that it is possible by mechanical means to reduce the size of territorial liabilities of the Empire by one-half and that if then it be still found that this half is too expensive for our defence forces, instead of scrapping bits of the Empire, we set to work to improve our means of movement so that our liabilities may be reduced to within the power of the securities which our depleted exchequer can afford us.

How shall we do this ? By making the present ends just meet ? No, for judging from every day business methods, as long as this can be done no improvement is to be expected. By demanding more money ? No, for accepting human nature as it is, the more we get the more shall we spend on war carts and stage coaches. The incentive will come through economy begotten of necessity. It is prodigality and not generosity which will compel reform, and reform to be economical must be preceded by a Renaissance in military thought. We must look back and discover deficiencies, we must look forward and estimate probabilities, we must be ready on the starting point with a clear cut scheme—a winning post, in front of us, for when the flag falls there will be no time wherein to make up our minds or look around. If we have not got a plan, we shall squander the little that is given to us ; this is a certainty.

I do not intend here to work out for you a mechanical system of

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defence for the Empire. I leave this to you, and I can conceive no more interesting problem. All I will now do is to place before you a few points which may guide your endeavours.

The first thing is to visualize clearly the object at issue. Which, to my mind, is not to fight another great war but to maintain the integrity of the Empire.

The second thing is to become thoroughly saturated with the principles of war and to check your reasoning by means of these at every step.

The third thing is to analyse very carefully the conditions which are likely to be met with, and especially those which affect movement.

The fourth thing is to keep your scheme sufficiently broad in order to embrace the Navy and the Air Force.

I will say a few words about the third and fourth.

Ground and Machines.—In the wars which face us it is not the enemy who counts but the nature of his country; uncivilized lands offer many difficulties, the two most important being deserts and mountains.

I do not intend here to tell you what a cross country machine can do in these areas outside mentioning to you that:—

(1).—In hill warfare, the main difficulty is the protection of supply columns.

(2).—In desert warfare, the obtaining of water.

A moment's thought will enable you to realize how cross country traction can modify these difficulties.

As regards the machine required, we shall not need a great umbering tank, but, for the main part, a light cross country chassis which can be fitted with either a lorry body, an armoured car body, or a tank body and which, as a lorry, can carry either five tons of supplies or water, or a field gun and 200 rounds.

A light speedy machine with a long radius of action is the type of machine I think we now require. It being both light and simple it can be easily built. Its cost complete would probably be well under £3,000.

Co-operation with the Navy.—Some years ago Sir Edward Grey made use of the following pregnant phrase:—"The British Army should be a projectile to be fired by the British Navy." If we consider for a moment the meaning of these words and then weigh them against our Imperial liabilities we shall realize what an enormous economy could be effected in our small wars if it were literally possible to shoot armies on to coast lines when punitive expeditions become necessary.

There is only one real difficulty in a combined naval and military operation, namely: ships cannot swim out of the sea and walk on

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land. . Because of this inability parties of soldiers have to be landed in lighters, rowing boats, pinnaces, barges, motor boats, and what nots, and in half an hour the beach is like Epsom Downs on a Derby morning.

It is the old difficulty of launching military coaches from a mechanical base, steamships in the present case replacing railways. If now, instead, from these ships floatable tanks and tractors be launched into the sea at say two miles from the coast line and are able to propel themselves ashore and crawl up the beach and move straight inland, confusion can be replaced by simplicity and surprise. It is so simple that people will not see it and I have been voted to Bedlam on several occasions for suggesting it, but I am not there yet. In a couple of years from to-day, I see no reason why such a mechanical force should not operate 1,000 miles from its naval base even in desert land such as central Persia.

Co-operation with the Air Force.—Punitive expeditions may, however, be required at greater distances than 1,000 miles from a naval base, how are we then to proceed? As from our battleships we launched our tanks and tractors, so from these should we now launch our aeroplanes, which should have no difficulty in extending our military influence over another 1,000 miles, that is 2,000 miles in all from the sea coast. The tanks will protect the landing grounds of the aeroplanes and the aeroplanes will carry supplies for the tanks.

With such a force Afghanistan can be attacked from its western side instead of from its eastern, or both sides can be attacked simultaneously if desired. Though I do not want once again to be voted to Bedlam or to share the fate of Solomon de Caus, nevertheless, as ships can carry tanks and tractors, I see no insuperable difficulty in aeroplanes doing the same, for machines weighing not more than 6 tons. Recently I have read a prophetic account of the next war written by a Belgian. He suggests carrying half a million men through the air. But why carry men? for at best we shall be depositing but military saddle horses (not even coaches) in our enemy's country. The "Sleepy Leeds" ceased to run because it was "no longer a profitable speculation." Masses of men do not pay, a few efficient machines do. If your strategy is based on mechanical power so must your supply system be and so must your tactics. This brings us to yet one more consideration.

Conclusion.—The soldier of the present must cease thinking purely in terms of land operations, for he must think in terms of sea and air warfare as well. To-day, warfare at sea and in the air is purely mechanical, on land it is still nine-tenths muscular. We cannot get unity of action until we have instituted unity of movement, in other words until our present muscular army has become a mechanical one.

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When this is accomplished we shall be like a runner equipped in seven league boots, like a boxer with an elastic arm ; standing in one corner we shall knock our opponent down in the other, for example, we shall be able to hit people in Teheran, before they know that we have left Tilbury. This, I think, is the Imperial military unity of action we should aim at, and the problem which faces not only a few of us but all of us in the immediate future.

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THE 3rd SAPPERS AND MINERS IN THE WAR.

By MAJOR A. L. PARIS, R.E.

HAVING read in the *R.E. Journal*, dated August, 1920, an account of how an ex-officer of the 3rd (late Bombay) S. and M. met with his old company in France, it has occurred to me that a short résumé of the doings of the Corps during the last six years will be of interest to many who have served or been associated with it in the past. We believe that our record in the war is second to none in the Indian Army, and that few have paid for their reputation more heavily in blood than the 3rd Sappers and Miners.

At the outbreak of the war, the units of the 3rd S. and M. were stationed as follows :—

Kirkee—17th Field Co. (old No. 1)—Capt. A. D. S. Arbuthnot, R.E. Subadar Baryam Singh, I.O.M.

Quetta—18th Field Co. (No. 2)—Capt. E. D. Tillard, R.E. Subadar Kudratullah Khan.

Quetta—19th Field Co. (No. 3)—Capt. E. J. Loring, R.E. Subadar Bhawani Singh.

Kirkee—20th Field Co. (No. 4)—Capt. A. L. Paris. R.E. Subadar Ganpat Mahadu.

Kirkee—21st Field Co. —Capt. J. S. Richardson, R.E. Subadar Malla Singh.

Kirkee—22nd Field Co.—Capt. A. M. Twiss, R.E. Subadar Keru Jamdade.

Aden—23rd Fortress Co.—Capt. C. F. Stoehr, R.E. Jemadar Lakshiman Powar.

At Headquarters at Kirkee were :—

Commandant—Lieut.-Col. U. W. Evans, R.E.
S. of I.—Major A. G. Bremner, R.E.
S. of P.—Major W. Bovet, R.E.
Adjutant—Capt. E. V. Binney, R.E.
Subadar-Major—Arjun Powar.
Regimental Sergeant-Major—W. H. Miers, R.E.

The general caste composition of the Corps, and the actual composition of most of the field units was quarter Sikh, quarter Mahratta, half Musalman (predominantly Panjabi), with a sprinkling of " other Hindus," never exceeding 10 per cent.

The first units to leave India were the 20th and 21st Companies, which went to France with the 3rd Lahore Division in August, 1914. They were the first Indian units to travel through France, and, after a short stay at Orleans, they reached the line S. of Estaires on 23rd

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October. On 28th October, being lent to the 3rd British Division, they, in company with 47th Sikhs, were ordered to retake Neuve Chapelle, which had been captured by the Germans the previous afternoon. This they did, and although they lost all their British officers, they held on to the village from 11 a.m. till dusk. This action has been very highly praised in all accounts of the doings of the Indian Corps in France, and Sir J. French's dispatch of 20th November, 1914, reads :—" On the 28th October especially the 47th Sikhs and the 20th and 21st companies of the Sappers and Miners distinguished themselves by their gallant conduct in the attack on Neuve Chapelle, losing heavily in officers and men." The nature of the fighting can be judged from the fact that of the 8 B.O.'s, 6 I.O.'s and approximately 300 I.O.R.'s who went into action the casualties were :— B.O.'s, 4 killed, 4 wounded (of whom 1 was captured) ; I.O.'s, 1 killed, 2 wounded ; I.O.R's, 45 killed, 71 wounded.

The companies soon pulled themselves together after this severe test, and took part in the 1st and 2nd battles of Ypres, Neuve Chapelle 1915, Festubert, and all the trench warfare of the Indian Corps up to November, 1915, earning a good name for both working and fighting. They stood the terrible winter trench conditions magnificently. Their casualties were regular and numerous, B.O.'s in particular suffering severely, having 24 casualties in six months, out of a strength of 8. All who have served in India realise what it means to Indian troops to know their officers, and it is greatly to the credit of both B.O.'s and Indian ranks that the companies did so well under officers who were strange to the men, and, in some cases, could not even speak their language.

The 20th and 21st companies left France with the Lahore Division in December, 1915, and went to Mesopotamia, coming in almost immediately for the heavy fighting of the Spring of 1916, when Generals Aylmer and Gorringe were striving to relieve Kut-el-Amara. Their total casualties up to 31st March, 1916, were :—

20th Company. — B.O.'s, 1 killed, 7 wounded (1 captured) ; B.N.C.O.'s, 1 wounded ; I.O.'s, 4 wounded ; I.O.R.'s, 41 killed, 3 died of disease, 151 wounded (1 captured).

21st Company.—B.O.'s, 8 killed, 10 wounded ; B.N.C.O.'s, 1 wounded ; I.O.'s, 3 killed, 5 wounded ; I.O.R.'s, 45 killed, 3 died of disease, 125 wounded (3 captured).

A Field Company strength at this time was :—B.O.'s, 4 ; B.N.C.O.'s 2 ; I.O.'s, 3 ; I.O.R.'s, 189.

The 17th and 22nd Companies left India with the 6th Poona Division for Mesopotamia in October, 1914. Their record there, till they disappeared into Turkey with the garrison of Kut-el-Amara, is one long story of good work and hard fighting. Like the 20th and 21st, they were sometimes used as infantry, and, like them also, were tested by continual losses of their B.O.'s, losing both the Company

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Commanders (Capt. Twiss killed, and Capt. Arbuthnot severely wounded); in their first action at Sahil on 17th November, 1914. They took part in the actions of Sahil, Kurna, defence of Shaiba, Barjasiyeh, Amara, Nasiriyeh, EsSinn, Ctesiphon, and defence of Kut-el-Amara.

Some of their numerous " mentions " are appended :—

Letter from the G.O.C. 16th Infantry Brigade to O.C. 22nd Field Company 3rd Sappers and Miners, No. B.M.1460, dated Shaiba, 16th April, 1915. " Brigadier General W. S. Delamain, C.B., D.S.O., commanding 16th Infantry Brigade, desires to express to all ranks of the No. 22 Company, 3rd Sappers and Miners, his very sincere thanks for their steadfast behaviour in the general action of the 14th instant and his admiration for the gallantry with which they pushed home an attack, in spite of heavy losses against a stubborn enemy who had the advantage of position and numbers. This is the second time in the campaign that the General Officer Commanding has had occasion to notice the gallant behaviour of No. 22 Company in action, and all ranks may be justly proud of having added greatly to the fine fighting reputation of the Corps. The General Officer Commanding regrets very deeply the loss of their gallant commander, Capt. E. C. Whiteley, R.E. (the second commanding officer who has fallen at the head of the company in the act of upholding the gallant traditions of the Sappers and Miners.)"

Dispatches of Sir John Nixon, Cmdg. Force D., dated 6th May, 1915 :—

Shaiba * * * * The brunt of these attacks fell on the 48th Pioneers and the 17th Company, 3rd Sappers and Miners, which units with ceaseless vigilance repelled every effort of the enemy * * * I wish to bring forward to special notice the very gallant defence made by the 48th Pioneers, and 17th Company, 3rd Sappers and Miners, who bore the brunt of the enemy's attacks. All ranks behaved with great steadiness and their vigilance and good shooting repelled all attempts of the Turkish forces to break through the defences.

Attack on Shaiba, 14th April, 1915.—It is impossible to conceive a more exposed tract of ground than the plain, devoid of cover, over which our infantry had to attack the Turkish trenches, cleverly concealed and sited. Our advance in the last 400 yards was down a glacis-like slope. It was on the crest of this slope that so many of our losses occurred. Splendid dash, combined with resolute courage, alone carried our men across that bullet-swept glacis. It was a sheer, dogged soldiers' fight, and no words of mine can adequately express my admiration of the conduct of those gallant regiments who won through, viz., 2nd Battalion Norfolks, 2nd Battalion Dorsets, 24th Punjabis, 110th Mahratta Light Infantry, 119th Infantry, 117th Mahrattas, 129th Infantry, 17th and 22nd Companies of the 3rd

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Sappers and Miners. It is gratifying to record the fact that all the Indian troops engaged (24th Punjabis excepted) are old Bombay Presidency Regiments. They have proved on this occasion that they are worthy to stand shoulder to shoulder with the best the Empire can produce and I trust that these corps may be permitted to inscribe the battle honour "Barjasiyeh" on their colours as a fitting tribute to their gallant conduct on this hard-fought field.

Dispatches of Sir John Nixon, Cmdg. I.E.F.D., dated 1st January, 1916:—

Nasiriyeh * * * At 5 a.m. on 24th July the attack was launched. * * * During this operation the gunboat *Sumana*, carrying bridging material, fought her way up to the entrance of the creek under a very heavy fire, and, supported by the fire from the gunboats, the 17th Company Sappers and Miners threw a bridge across.

Es Sinn * * * The first troops to enter the enemy trenches were the 2nd Battalion Dorsetshire Regiment, 117th Mahrattas, and 22nd Company Sappers and Miners, who made a brilliant assault, well supported by the artillery, and soon after 10 a.m. captured a redoubt and trenches on the enemy's extreme left, inflicting heavy losses, and taking 135 prisoners.

The casualties up to 31st March, 1916, were:—

17th Company.—B.O.'s, 2 killed, 5 wounded; B.N.C.O.'s, 2 wounded; I.O.'s, 2 killed, 3 wounded; I.O.R.'s, 15 killed, 21 died of disease, 81 wounded.

22nd Company.—B.O.'s, 3 killed, 2 wounded; B.N.C.O.'s, 1 wounded; I.O.'s, 1 killed, 4 wounded; I.O.R.'s, 37 killed, 11 died of disease, 108 wounded.

With the surrender of Kut, the war career of the 17th and 22nd Companies ended. About two-thirds of the men lived through their two and a half years of captivity, and eventually returned to Kirkee. But, very unfortunately, the old companies were never re-formed. The present 17th and 22nd companies are not the original ones, but are the war-formed 101st and 104th Companies re-numbered. Perhaps this was unavoidable, but it is nevertheless very regrettable. The 17th was the oldest and 22nd the youngest of the pre-war field companies.

Another Corps unit engaged early in the war was No. 5 Pontoon Park, which sailed with the I.E.F. "B," to East Africa in October, 1914, under Capt. Tillard. It took part in the capture of Mafia Island, and Bakoba, the advance on Moshi, and the subsequent operations in German E. Africa in the Pangani and Rufiji Valleys. It was employed chiefly on bridging, hutting, road-making, and water supply. In spite of the climate, the health of the company was good, at any rate for 18 months; later there was considerable sickness. This unit returned to India, and was disbanded in March, 1918.

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The 23rd Fortress Company at Aden was also soon engaged. It took an active part in all the operations round Aden, including the advance to Lahej in 1915, and subsequent retirement, also the fighting in August-September, 1915, and January, 1916. The Company also was not infrequently employed as infantry.

After the operations for the relief of Kut, the 20th and 21st Companies were joined in Mesopotamia by the 18th Company, which left India on 9th June, 1916, under Capt. Binney. With the Lahore Division, these three companies took part in all the operations culminating with the capture of Baghdad, and in the subsequent fighting on the Diyalah. In 1918, they went to Egypt and Palestine, arriving in time to participate in the great final victory over the Turks. They received the following appreciation from Maj.-General H. D. Keary, Cmdg. 3rd Lahore Division :—" Farewell order to the Sappers and Miners, 3rd Division, Mesopotamian Expeditionary Force.—On leaving the 3rd Division I desire to record my appreciation of the splendid work done by all ranks of the 18th, 20th, and 21st Companies, 3rd Sappers and Miners. The 20th and 21st Companies have been with the Division since its arrival in France, and with it have taken part in numberless battles of the first magnitude. Since the day on which they, in conjunction with the 47th Sikhs and 9th Bhopals, captured the village of Neuve Chapelle in October, 1914, to the battle of Jebel Hamrin in March, 1917, these two companies have held a record of gallantry and fine fighting spirit second to none. Among other feats must be mentioned that of Capt. Arbuthnot and his handful of men who held on to the Dujailah Redoubt to almost the last man against overwhelming odds. To enumerate all the fine achievements of these two companies would be too lengthy for the purposes of this order ; suffice it to say, wherever and whenever they have been called upon to assist in battle they have responded nobly. As sappers their toil has been unceasing, by day and by night, digging, wiring, bunding, bridging, or sapping, all three companies have laboured unremittingly under all conditions of enemy's fire, floods, heat, cold, and privation, with the utmost cheerfulness and zeal. No troops could have harder or such long hours, while the quality of work has shown ingenuity and skill of a high order. I must especially thank Colonel Stack for his power of command and for his readiness and resources under every conceivable emergency. It would be invidious to mention any others by name where all have done so well, but I can truly say it would be hard to find a finer lot of officers anywhere. I wish all ranks farewell and every good fortune, with the assurance that I shall not readily forget my association with the above three companies of the 3rd Sappers and Miners."

The 19th Field Company, as a unit, did not leave India until 10th November, 1917, but long before that date practically all its pre-war *personnel* had joined other corps units, as drafts. In

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November, 1917, the Company joined the 13th Division in Mesopotamia, and in April, 1919, went to N. Persia.

The casualties of the Corps were far less in the last two than in the first two years of the war; once the companies left France and the Mesopotamia fighting that ended with the fall of Kut, and the abandonment of attempts to relieve it, was over, they became comparatively light. Many new units were formed, and in the list which follows is shewn the theatres of war in which the Corps has been engaged, including the recent operations in India and Persia.

The 20th and 21st Companies arrived at Kirkee on 17th August, 1920, after exactly six years' absence. Only about a dozen men were left in them of those who sailed in August, 1914. The most striking record is perhaps that of Liakat Ali, 21st Company, who left in 1914 as a sapper, fought through the war, and survived to lead his company home over Holkar's Bridge once more, as its subadar.

No war history of the Corps can be complete without reference to the sterling work of the following, who all served throughout the war at Kirkee, and to whose unremitting labour in the duties of a depôt is chiefly due to the fact that, after its first heavy casualties, the Corps was able to maintain its strength and reputation in the field:—Subadar Major Arjun Powar; R.S.M. W. H. Miers, R.E.; Q.M.S. (later Lieut.) J. W. Maun, R.E.; Q.M.S.I. W. Rice, R.E.; Subadar Poshati Mari. Not only had the depôt to keep our original units up to strength, but also to enlist and train sufficient men to raise the Corps to two and a half times pre-war strength.

Personal Notes on a few of the older Indian Officers.

Subadar-Major Arjun Power.—Senior I.O. of the Corps; at Kirkee throughout; responsible for every recruit enlisted. Bahaduri. Lieutenancy 1.7.20. Pensioned 1.8.20, with 31 years' service.

Subadar Poshati Mari.—Senior F.W. Instructor; at Kirkee through out; literally worked till he dropped. Bahaduri. Died at Kirkee, still in harness, on 2.3.20, with 35 years' service.

Subadar Malla Singh.—With 21st to France. Neuve Chapelle gained him great honour, but broke him up. Returned to Kirkee, and died there on 2.11.19. Bahaduri; I.O.M.; M.C.

Subadar Baryam Singh, *I.O.M. (pre-war).—With 17th to Mesopotamia; died of wounds in Kut during siege. Bahaduri.

Subadar Ismail Khan.—With 21st to France as Jemadar; later Subadar. Wounded. Bahaduri; I.D.S.M.; Russian Cross of St. George. Pensioned as unfit on account of wounds, but re-engaged for depôt, and is still Senior F.W. Instructor at Kirkee.

* Our other pre-war I.O.M., Naik Nuruddin, was killed at Neuve Chapelle, 1914.

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Subadar-Major Firoz Ali.—With 22nd to Mesopotamia as Jemadar, then Subadar. Wounded. Became Subadar-Major of a Labour Corps, but returned to Kirkee later. Bahaduri, I.O.M. Lieutenancy 1.7.20. Shortly goes to pension.

Subadar Mohamed Din.—With 17th to Mesopotamia as Jemadar. Later Subadar of 22nd. Captured at Kut. Wounded. I.O.M. Bahaduri. Still serving.

Subadar Ramswami Naidu.—With 22nd to Mesopotamia as Jemadar. Later Subadar. Wounded, later killed. I.O.M. 2nd class. I.O.M. 1st Class.*

Subadar Ali Bahadur.—Joined 20th, and later 21st, in France. Wounded and lost a leg. Pensioned. I.D.S.M.

Subadar Keru Jamdade.—With 22nd to Mesopotamia. Wounded in first action. Pensioned.

Subadar Shah Sawar.—To 21st in Mesopotamia. Wounded in 1916. Bahaduri. Now Subadar of 19th Co.

Subadar Bir Singh.—To 21st as Jemadar. Now Subadar of 17th Company. I.O.M. Wounded.

Subadar Ganpat Mahdu.—With 20th to France. Wounded. Bahaduri. Now Subadar of 71st Company.

Theatres of War in which Units of the Corps have served.

France and Flanders.—20th and 21st Field Companies.

Mesopotamia.—17th, 18th, 19th, 20th, 21st, 22nd, and 104th Field Companies. 3rd Bridging Train, No. 2 Engineer Field Park, Nos. 5, 6, and 10 Printing Sections, Nos. 5 and 8 Photo-Litho Sections, Karun Front Section.

East Africa.—No. 5 Pontoon Park.

Egypt and Palestine.—18th, 20th, 21st, 72nd, 76th, 80th, and 101st Field Companies, 2nd Field Squadron.

Aden Field Force.—23rd Fortress Co., Aden Defence Light Section.

East Persia.—Seistan Detachment, 71st Field Company, 73rd Field Company (2 Sections), No. 5 Photo-Litho Section.

Marri Punitive Force.—71st Field Co. (1 Section), 72nd Field Co.

Afghan War.—17th Field Company (2 Sections), 24th Field Company, 73rd Field Company (2 Sections), 74th Field Company (2 Sections), 75th, 76th, and 80th Field Companies, 4th and 7th Field Troops, 6th Pontoon Park, No. 2 Engineer Field Park, No. 7 Printing Section, No. 6 Photo-Litho Section.

Waziristan Field Force.—74th and 75th Field Companies.

* Our other two 1st Class I.O.M.'s were Jemadar Gurmukh Singh and Naik Sone Singh.

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AN EXPLORATION IN SOUTH-EAST TIBET.

By MAJOR H. T. MORSHEAD, D.S.O., R.E.

INTRODUCTION.

IN the following pages I propose to give a short description of an impromptu journey undertaken in 1913—the year before the war—with a view to proving the identity of the Tsangpo River of Tibet with the Bramaputra of the Plains of Assam.

Light literature on the subject of travel and exploration being somewhat alien to the austere pages of the *R.E. Journal*, it will perhaps be well to confess at the outset that this article is merely an account of a few personal adventures ; it contains no new contribution to the art of war in general nor a single suggestion for the improvement of survey methods in particular.

THE TSANGPO PROBLEM AND PREVIOUS ATTEMPTS AT ITS SOLUTION.

Before commencing my story it may not be amiss to recall the history and nature of the long-standing geographical problem presented by the Tsangpo River, and to explain briefly the circumstances which led up to its successful solution seven years ago.

The upper course of the great river from its source near the Manasarowar Lake to the town of Tsetang, south-east of Lhasa, was first made known to us through the journey of the Indian explorer, Pandit Nain Singh, C.I.E., who was trained by Capt. T. G. Montgomerie, R.E., of the Survey of India, and whose original journey in the years 1865–66 resulted in a reliable route map of the first six hundred miles of the course of the river.

With a view to tracing the lower course of the Tsangpo and of proving its identity with the Dihang branch of the Brahmaputra River of Assam, Capt. Harman, R.E., of the Survey of India, enlisted in the year 1880 a Chinese lama whom he instructed to proceed as far down the river as possible and to throw marked logs into the Tsangpo. Watchers were to be stationed at the junction of the Dihang and Brahmaputra to note the arrival of these logs. The lama took with him, as servant or companion, a native of Sikkim, Kinthup by name, who had previously accompanied another Indian explorer on a journey in the same neighbourhood. On arrival at a place called Tongkyuk dzong, near the borders of China, the lama, becoming apparently " fed up " with his errand, sold Kinthup into slavery and returned to his own home in China, never to be heard of

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again. Kinthup managed to escape and returned to Darjeeling after an absence of four years—having traced the course of the Tsangpo nearly 100 miles lower than any previous explorer, until turned back by the savagery of the Abor tribes within some 40 miles of the Plains of Assam. He even carried out the programme of throwing 500 marked logs into the river, but Capt. Harman had in the meantime died—a victim to over-work—and the logs floated unowned and unnoticed into the broad bosom of the great river of Assam.

Kinthup being quite illiterate could only dictate his experiences from memory on his return, and his information not being based on any route survey added little to the map of South-east Tibet. One alleged statement of Kinthup's created considerable interest, namely, that "at a place called Sinji-Chogyal the river falls over a cliff from a height of about 150 feet, a big lake lying at the foot of the falls, where rainbows are always observable." Falls of such a height are absolutely unknown on any of the great Himalayan rivers and are, indeed, almost an impossibility in an area of such geologically recent formation, where the strata are largely composed of uncompacted shales. Yet without postulating the existence of falls it seemed difficult to account for the huge drop in the bed of the river from 12,000 feet in the neighbourhood of Lhasa to its emergence into the Plains of Assam at a height of 500 feet above sea level.

Harman's death marked the end of the era of native Indian exploration which had produced such grand results during the previous 20 years, and interest in the Tsangpo problem lapsed until the military and political expedition to Lhasa under Colonel Younghusband in 1904–5. This expedition was accompanied by a fully-equipped Survey party under Major C. H. D. Ryder (now Colonel Ryder, C.I.E., D.S.O., R.E., Surveyor-General of India) and it was confidently hoped that at the close of the campaign an opportunity might occur for a small survey party with escorts to return to India *viâ* the lower course of the river, and thus settle the problem once and for all. Political conditions, however, rendered this impossible, and the survey party proceeded up-stream instead of down—carrying out a rigorous survey of the Upper Tsangpo Valley and of the Northern Slopes of the great Himalayan range, and amplifying and confirming Nain Singh's route traverse of 40 years before.

Six years later various events on the North-east Frontier combined to focus attention on this little known area. A punitive expedition, accompanied by a Survey party, was sent into the Abor Hills in the cold weather of 1911–12; other survey parties under military police escort were at the same time organized for work in the neighbouring valleys of the Subansiri River (Miri tribes) on the west, of the Luhit River (Mishmi tribes) on the east, and of the headwaters of the Irawadi (Kachin and Shan States) from the Burma side, with a view

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to the complete mapping of the Indian N.E. Frontier. As the work was not completed during the cold weather season, 1911–12, these parties were again sent out in the following season, 1912–13.

At the close of the second field season in May, 1913, the position was as follows:—The Abor Survey Party, under Capts. Trenchard and Oakes, R.E., had surveyed the basin of the Dihang River and its principal tributaries, as far north as latitude 29° 15′ approximately (*vide* accompanying map). The Mishmi Survey Party, under Major Gunter, R.E., and the present writer, had completed the survey of the whole basin of the Dibang River, which had been proved not to pierce the main Himalayan range to the north. During the course of the latter operations a colony of Tibetans from the province of Kham was discovered at Mipi village in the upper valley of the Matun branch of the Dibang River. These Tibetans, who proved friendly, volunteered much interesting information regarding their own native country, and offered to provide guides to point out the road thither. It was felt that a unique opportunity was thus offered for a small party to penetrate the unknown reaches of the Tsangpo in the neighbourhood of the great bend, and thence possibly to follow the hitherto unexplored Frontier westwards towards Bhutan.

By great good fortune the Assistant Political Officer with the Mishmi party was Capt. F. M. Bailey, I.A., a man of boundless physical energy, a born naturalist and explorer, and possessing an intimate knowledge of the Tibetan language and customs.

Our Journey—Pemakö, Pomé, and the Great Bend.

On the conclusion of the Mishmi Survey Operations, Bailey and myself, with ten picked coolies remained behind in Mipi, where we had been able to store a two months' supply of rations and a complete outfit of warm clothing for our small party.

Having spent the first half of May in laying out depôts of rations, as far in advance along the road as the now rapidly receding snow-line permitted, we finally quitted Mipi with our ten coolies and three local guides, in pouring rain, on May 16th. The going was extremely bad, as the incessant rain and the rapid melting of the snow on the hills had combined to render the whole country a morass. Our marches were therefore short; we had, moreover, to make several halts while our coolies returned to fetch up the reserve of rations; so that it was not until 24th May that we reached the "Latsa," or hut, at the foot of the Yonggyap Pass. The next day snow fell heavily all day and our guides declared that it would be madness to attempt the Pass. On the 26th, the weather having slightly improved, we started early—ourselves carrying guns, plane-table, etc., so as to have every possible coolie available for carrying rations. Owing to a thick mist, our guides had great difficulty in finding the

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Pass, which is reached by a toilsome ascent of some 1,500 feet through deep snow, and it was dark when we reached the "Latsa" on the north side of the Pass. Here we had to halt for a day, as four of our coolies were totally incapacitated by snow-blindness. There had been no apparent glare on the snow, owing to the dense mist all day, and the possibility of snow-blindness had not occurred to us. However, we received a lesson thus early by which we were not slow to profit. We were now in the valley of the Shümo, or Yonggyap River, a tributary of the Dihang, or Tsangpo.

A peculiar Tibetan characteristic may here be mentioned, namely, that of giving the same name to the two streams which flow in opposite directions from the two sides of a mountain pass. Thus from the Yonggyap Pass, one Yonggyap stream flows S.E. to join the Dibang River, while another stream of the same name flows W. to join the Dihang River.

Since leaving Mipi, not a single triangulated peak had been visible through the cloud and mist, and I began to realize the impossibility of carrying on any system of connected triangulation, or indeed, of executing any more rigorous method of survey than a route traverse by "time and compass."

One march from the "Latsa" Camp brought us to Yonggyap Da, where the streams from the Yonggyap and Pungpung Passes unite. The combined waters of these two streams join the Dihang under the name of the Shümo River. There is, however, no road down the Shümo Valley, and in order to reach the Dihang it is necessary to cross the Pungpung Pass, and follow the Chimdro stream to its confluence with the Dihang near Kapu. Just above Yonggyap Da there is a shallow lake, some two miles long by half a mile wide, formed by the damming of the stream.

On the 30th May we crossed the Pungpung Pass (14,310 feet by hypsometer), which, like the Yonggyap, was under 20 feet of snow, and next day reached the village of Gudam in the Chimdro Valley—the first human habitation which we had seen since leaving Mipi fifteen days before. From Mipi to Chimdro is a distance of nearly 100 miles through uninhabited country in which no supplies of any kind are procurable. The journey, moreover, involves the crossing of two passes which, though not exceedingly high, are yet dangerous on account of their proneness to constant snow storms and mist. The necessity of providing food for the whole party for this portion of the journey had greatly curtailed our carrying capacity; though we were able largely to supplement our food supply by shooting pheasants—three varieties of which, munal, tragopan, and blood pheasant, were very plentiful just below the snow-line.

At Chimdro, Bailey succeeded in inducing the local "dzongpen," or Tibetan official, to provide us with coolies and supplies for our onward journey. This was a most important achievement, since our

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title to supplies and transport, thus once admitted, served as a precedent for the whole of our journey.

On the 5th June we reached Kapu in the Dihang Valley, and heard that the Abor Column were some 6 marches down stream. This portion of the Tsangpo valley below the great bend is known as Pemakö. It was originally inhabited by wild Abor tribes, but the latter were ousted 100 years or so ago by immigrant "Mönbas" or Bhutanese. The latter are, of course, Buddhists by religion, and still like to consider themselves Bhutanese subjects, though actually they are subjects of Pomé. From Kapu I sent a letter by native runner to Trenchard informing him of our arrival, and asking for the co-ordinates of any triangulated points which he might have fixed. While waiting for a reply we traversed leisurely down the Dihang Valley, halting at Makti (where a brief interval of clear sky enabled me to observe N. and S. stars for latitude) and finally ascending a side spur to the monastery of Rinchenpung. The river is here some 120 yards wide and the current very fierce. It is spanned here and there by single-rope bridges of twisted cane which have to be crossed "hand-over-hand" in monkey fashion—the weight of the body being supported by leather thongs fixed to a wooden saddle which slides over the rope. The river level at this point is about 2,600 feet, and the densely-wooded sides of the valley rise steeply on either hand to a height of 6,000 or 7,000 feet. Villages occur every few miles along the lower slopes of the valley on either bank. The moist, damp heat of the valley at this time of the year is most trying; combined with the perfect plague of mosquitoes, leeches, and gadflies, life would have been rendered almost unbearable were it not for the very excellent quality of beer which is brewed here in large quantities from millet.

After vainly waiting three days for a reply to my letter, we retraced our steps to Kapu, and thence continued up the valley *viâ* Kemteng and Tsangrang to Lagung, where we found the "Nyerpa," or Prime Minister of Pomé, Namgye by name, waiting for us. Namgye was returning from a winter tour in Pemakö, and had been in correspondence with the Abor Column, who had informed him that they did not intend to penetrate into Pemakö. He was, therefore, inclined to view us with considerable suspicion, regarding our arrival in the country as a breach of faith. Finally, it was settled that we were to abandon our intention of following up the valley of the Tsangpo, and were to accompany him over the Sü Pass to Showa, the capital of Pomé, where a council would be held as to our disposal.

We halted two days at Lagung. The Nyerpa came to see us on the morning of the second day, bringing a present of rice, tea, etc. He was less on his dignity than before, and had a long conversation with us. He had with him a number of Chinese matchlocks, and in the afternoon, by way, apparently, of impressing us, he fired off a

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number of rounds at a mark. We joined in with a round or two from our own rifles. In the evening he came again to see us—very friendly, but as drunk as a lord.

We crossed the Sü Pass on 23rd June, and by judiciously lagging behind the Nyerpa's party, I was able to fix accurately the position and height of the Pass (13,445 feet) by trigonometrical interpolation by means of a surreptitiously observed sun-azimuth to the two previously triangulated peaks of Namcha Barwa. The crossing of the Pass involved a climb of 2,900 feet over snow which was quite hard and easy to travel over, though in places the leading man cut steps with his sword.

On the Pass we saw "munal" pheasants, and another strange game bird resembling the "ram-chukor," which we were unable to identify as unfortunately the only specimen which I shot fell 500 feet down the hillside and was lost under a snow-drift.

We reached Showa on June 25th, and were kept more or less prisoners in the travellers' house for three days, during which time Bailey spent many hours pressing our case before the Council, who affected to believe we represented a Southern flank attack on the part of the Chinese who had been expelled eastwards out of the country 18 months previously. Matters were eventually settled satisfactorily, and we were given a mounted guide and promises of supplies and transport to take us to the Tibetan border; though, at the very last moment their suspicions were again aroused, and the negotiations imperilled, at the sight of the Chinese writing on the tablet of Indian ink which I was using in inking up my plane-table.

In the Pomé valley one first began to notice a change in the type of scenery and vegetation from that of the Abor and Mishmi Hills. The dense tropical jungle of the lower Dihang valley gives way to tall pines and cypresses growing from a carpet of lush grass and vivid-coloured wild flowers; while the substantial stone-built houses, terraced fields, and avenues of peach, walnut, and pollard, willow denoted a higher type of civilization than we had hitherto met. Showa, the capital of the country is a straggling village of perhaps 40 houses, situated on the south bank of the Po-Tsangpo. There are the remains of a large palace and monastery, which, together with the bridge over the river, were destroyed by the Chinese during the frontier fighting of 1911. A fine new cantilever bridge of 50 yards span had just been completed.

The Pobas, or inhabitants of Poyul (the Po-Tsangpo Valley) claim to be independent of Lhasa, although actually they apparently pay a small annual tax to Lhasa. This tax is paid in kind, in the form of butter, madder dye, and sulphur. The Pobas have the reputation amongst their neighbours of being a tribe of wild robbers. They certainly raid the countries bordering their own frontier, and the Tibetans of Kongbo subsequently told us that we were extremely

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lucky in getting through Pomé alive, as they usually kill all travellers who are worth looting. This is no doubt an exaggeration, but it shows the feelings entertained towards the Pobas by other Tibetans.

We were much struck by the immense volume of water carried by the Po-Tsangpo, which is here some 80 yards in average width, deep, and with a very fierce current. We were very anxious to explore this river to its sources on the Chinese frontier, but this the Nyerpa flatly refused to countenance—alleging as a reason that the inhabitants of the upper valleys were bandits and robbers.

Up to this point I had endeavoured, as far as possible, to conceal the fact that I was making a map ; for which reason, and also owing to the incessant rain, I had avoided using the plane-table, contenting myself with a rough prismatic compass traverse, which was plotted in the evenings. Having now made friends with the Nyerpa, I explained my business to him, showing him the whole of my instruments, etc., to which he made no objection. He remarked, indeed, that once many years previously a Chinaman had come from the west, and had attempted to march through the country counting his paces and writing the numbers down in a book, but that in accordance with the custom of the time, he had been bundled out of the country by the way he came, with the intimation that such things were not done in Pomé. This may have been the Chinese monk referred to on a previous page, who decamped after selling Kinthup into captivity.

I may here remark that the policy then initiated of absolute openness in regard to the object of our journey, and the making of the map, proved completely successful. No serious objection was ever made to our operations, and we had the priceless advantage of being able to work openly and with an easy conscience.

Having meantime received Trenchard's reply to my letter, we left Showa on the 28th June, and in two days reached the villages of Tang-Tö and Tang-Me (Upper and Lower Tang), where our journey down the Po-Tsangpo was stopped by a broken bridge over the Yigrong affluent, necessitating a two days' excursion up the valley to a ferry on the Yigrong Lake. The story of the formation of this lake as told us by the natives is worth recording. Some 13 years previously the Tralung stream, a small tributary of the Yigrong ceased to flow for three days, while rumblings were heard up the valley. Suddenly, at 2 or 3 o'clock in the afternoon an immense, mass of mud and stones came down the valley completely engulfing two villages at the mouth of the stream, as well as two more on the opposite bank of the Yigrong, and forming a dam across the river some 350 feet high and 1¼ miles in width. For a month the Yigrong remained completely dammed, while a huge lake gradually formed ; finally the dam was topped, and the pent-up water was released to form the famous flood which was noticed in Assam in the year

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1900 as carrying the corpses of strange men and pine-trees of an unknown variety. Fourteen miles down stream from the lake, we were shown the site of an old village, 170 feet above the present river level, which was washed away in this flood. The lake to-day is nearly 10 miles long and ¾-mile in average width, and though the Yigrong is still cutting away the dam, it is probable that the lake will have filled with silt before the original level of the river bed is reached. Many villages and fields were submerged by the rising waters of the lake, the owners of which, wandering southwards in search of new homes, founded the colony of Mipi in the Mishmi hills.

The hills on either side of the Yigrong Lake contain iron ore. A vein at the S.E. corner of the lake is worked by means of a horizontal adit extending some 600 feet into the hill-side. The ore is smelted on the spot, and made into swords which are traded in Kongbo and Pemakö.

We camped for a day on the edge of the lake, in order to enable us to map its northern extremity. Bailey took advantage of the opportunity to go off shooting and returned to camp in the evening with a new species of "Gooral," which has subsequently been named "Nemorhaedus Baileyi."

On July 9th we reached Trulung. Here the road down the valley to Pemakö crosses to the left bank of the Po-Tsangpo, but the single-rope bridge which spans the river had been carried away a few days prior to our arrival, and we were consequently unable to carry out our intended programme of making good the section of the river down to where we had left it at Lagung. It may be here remarked that the bridges of Pemakö and Pomé, which are all of the "single-rope" type, are usually carried away when the rivers rise in June, and are not renewed until the following cold weather, so that travelling is only possible during the winter and spring.

From Trulung we therefore followed the Tibet road up the Rong River *viâ* Tongyuk dzong (the site of Kingthup's captivity) and the Nyima Pass (15,240 feet) to the village of Pe, on the Tsangpo, which we reached on July 13th. The river is here broad, deep, and placid, and we were rowed across to the south bank in a ferry boat. We were now in the Tibetan province of Kongbo. We were informed that two officers (whom we afterwards ascertained to be Capts. Trenchard and Pemberton, R.E., of the Abor party) and some Gurkha Sepoys had arrived here from Pemakö seven days previously *viâ* the Doshong Pass, and had returned after a halt of one day. We met the dzongpen of Tsela and other officials who had hurried to Pe on hearing of the arrival of the strangers, and from them we were able to obtain passports, which helped us materially for the remainder of our journey in Tibet.

Having collected a supply of rations we followed down the right bank of the Tsangpo to Gyala. This is the last Tibetan village of

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any size on the Tsangpo during its course in Tibet proper, and is the headquarters of a "depa," or sub-official, subordinate to the dzongpen of Tsela.

Hearing some pheasant calling just outside our camp at Gyala, Bailey rushed out with his gun and a few cartridges and presently returned with half a dozen specimens of the extremely rare "Harman's pheasant." This bird is named after the late Capt. Harman, R.E., of the Survey of India, who in 1880 obtained from one of his Tibetan explorers a single imperfect skin of an unknown " eared " pheasant. This he sent to the British Museum, where it was described under the name of *crossoptilon harmani*, and remained the only known specimen of its species until Bailey's lucky find 33 years later. The bird is large and of a uniform slaty-blue colour, with red back, legs, and eye-patches.

Across the river on a small side stream are the falls of Shingche Chogye. The limestone rocks which from the bed of the stream have been hollowed out into curious caverns by the water, which falls n three successive cascades of some 50 feet each, into the Tsangpo below. A demon who gives his name to the falls is popularly supposed to be chained behind the falling waters, but is only visible at times of very low water.

Below Gyala the valley narrows and the Tsangpo gradually changes from a placid river into a roaring torrent. Pemakö-Chung which we reached on July 21st is the last Tibetan habitation. It consists merely of a humble monastery and one other occupied house. A mile or so above the monastery the Tsangpo falls over a cliff some 30 feet in height, and from here onwards can only be described as a seething, boiling mass of water. I was able to fix in the position of these falls accurately by trigonometrical interpolation from the peaks of Namcha Barwa which towered overhead 5 miles to the south. While I was working on the edge of the falls, four huge " takin " were gazing and basking in the sun on the opposite (north) bank of the river not 80 yards away. Only three specimens of this extremely rare animal had at that time ever been shot by any European, and the temptation to empty my rifle into the four ungainly unconcerned forms was almost irresistible. However, to collect their bodies would have involved at least 10 days' delay in returning up-stream to the nearest bridge at Gyala and down the other side, and as we could ill afford the time I spared their lives.

We were told that there was absolutely no road down the valley to Pemakö ; we determined, therefore, to cut a road for ourselves as long as our rations lasted, and succeeded in reaching a prominent spur, 13 miles further down the valley from which I was able to trace the general alignment of the Tsangpo for the next 30 or 40 miles of its downward course, as well as to fix the general position of the high, snowy range round which the Po-Tsangpo flows N.W. of the Sü Pass.

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Returning to Pemakö-Chung we found that during our absence a party of "Mönbas" from Pemakö, escorting a holy lama on a pilgrimage to Lhasa, had cut themselves a road up the Tsangpo Valley, following the water's edge. This was said to be the first time for 20 years that there had been any direct communication through the gorge of the Tsangpo River, between Kongbo and Pemakö. Our rations were unfortunately now almost exhausted, so I returned to Gyala, while Bailey with a single coolie followed some of the returning escort and succeeded in getting a few miles below our previous limit when the Mönbas deserted him at an almost impassable precipice, and he was compelled to return, after taking a hypsometer reading at the lowest point reached on the river. In going through the thick jungle at this spot, Bailey had the misfortune to lose his camera—the only one we had with us—and we have no photographic record of the remaining portion of our journey.

Bailey questioned numerous natives regarding the portion of the river unvisited by us, whose length we estimated at 45 miles. They are unanimous in asserting that it continues the same seething, boiling current, but that there are no actual waterfalls as large as the falls at Pemakö-Chung. The following table A exhibits the heights and gradients of the Tsangpo River in the neighbourhood of the great bend. Table B gives similar information for the lower reaches of the Po-Tsangpo.

TABLE A.

Places on the Tsangpo.	Height in feet.	Fall in feet.	Distance in miles.	Gradient in feet per mile.	Remarks.
Nyuksang	8732				
Pemakö-Chung (top of falls) ...	8381	351	14½	24	
Sanglung confluence	8089	292	3	97	
1½ miles below confluence... ...	8010	79	1½	53	
2 miles below Churung confluence	7477	533	11	49	
Gompo-né (assumed)	5700	1777	20*	89	Confluence of Tsangpo and Po-Tsangpo
Chimdro confluence	2606	3094	75*	41	

TABLE B.

Showa (river level)	8312				
Tangmé (river level)	6751	1561	31	50	
Trulung (river level)	6424	327	10½	31	
Gompo-né (assumed)	5700	724	25*	29	
Yigrong Lake	7301				
Tangmé	6751	550	17½	31	

*Assumed distances. Of the seventy-five miles between Gompo-né and the Chimdro confluence, 45 miles were mapped and the remaining thirty miles filled in from native information. Diplomatic reasons prevented our obtaining a hypsometric observation of the river-level and Lagung where we quitted the Tsangpo valley.

In this table a height of 5,700 feet has been assumed for the junction of the Tsangpo and Po-Tsangpo at Gompo-né, on the assumption that the gradient of approximately 30 feet per mile deduced for the latter river, continues as far as the confluence.

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Fortunately, while we were at Pemakö-Chung a spell of bright sunny weather occurred, which enabled me to survey this portion of the valley by accurate fixings from Namcha Barwa and the neighbouring triangulated peaks and also to fix the prominent groups of snows on the opposite bank of the river which culminate in the magnificent peak of Gyala Peri (23,460 feet) never before seen by any European. The stupendous nature of the Tsangpo gorge may be realized when it is remembered that the peaks of Gyala Peri (23,460 feet) on the N. and Namcha Barwa (25,445 feet) on the S. are less than 14 miles apart in a straight line, while the level of the Tsangpo River, which flows midway between them is only 8000 feet—thus on either hand the mountains rise 15,000 feet in a horizontal distance of less than seven miles.

Bailey having rejoined me at Gyala on August 3rd we crossed the river by a single-rope bridge and returned by the N. bank to Pe. There had been a ferry boat at Gyala in additon to the bridge, but unfortunately just before our arrival a woman had attempted to ferry herself across alone in the boat and was carried down-stream; neither the boat nor the woman were ever seen again; they had doubtless been dashed to pieces in the rapids below. The bridge consisted of a single-rope 150 yards long, and 50 feet above the water in the centre; the sag in the middle was so great as to render the pull-up on the far bank a considerable acrobatic feat, and the hauling across of all our baggage piece by piece was a heavy task.

Our Journey (*continued*)—S.E. Tibet, and the Head Waters of the Subansiri.

From Pe to Tsetang, which we reached on 29th August, the road calls for little comment. With the exception of two large bends in the river, which the road avoids by short cuts over spurs *viâ* the Kongbo-Nga and the Putrang Passes, there is a good riding road for the whole 300 miles on both banks of the river. We followed the N. bank as far as Tu, in the hope of obtaining a view of the triangulated peaks of the main Himalayan watershed to the S.; this, however, was not possible owing to the dense clouds due to the Indian monsoon.

Harvesting operations were in full swing in the villages through which we passed. The barley, which is the only crop grown at these altitudes, is threshed at once and parched whole on large flat iron plates, after which it is ground into a dry ready-cooked powder called "tsampa," which, mixed with tea or beer, forms the staple food of the country.

For some 80 miles above Pe the Tsangpo flows in a broad placid stream with numerous sandy islands and spits. Further upstream the valley again narrows, and from Orong and Gacha to within a

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few miles of Tsetang the river is broken and rapid. The Gyamda Chu, a large river flowing in a wide alluvial valley, joins the Tsangpo at Tsela, and is noteworthy as being the only important exception to the remarkable observed fact regarding the Tsangpo, namely, that its tributaries join the main river at an angle opposed to the direction of flow of the main stream.

Tsetang, which had previously been visited by Pandit Nain Singh and other Indian explorers, is a town of 200 or 300 houses. We found here a small colony of Kashmiri Mohommedan traders from whom we were able to buy a fresh outfit of boots and clothes for our coolies, as well as a few luxuries, such as brick tea, soap, and sugar for ourselves.

From Tsetang after a two days' halt we followed the road of Nain Singh and others southwards up the wide fertile Yarlung Valley, and crossed the Yar-tö-Tra Pass (16,700 feet) to Chumda Kyang. We were now in the typical "*Chang tang*," or elevated plateau country of Tibet, far above the level of trees or fuel, and where no crop will ripen, save a little stunted barley. Villages here are few and squalid, and the undulating stony plains are void of all detail, except where a few black yak-hair tents and scattered flocks of sheep and yaks mark the presence of a "*drok*" or grazing camp. Fierce, icy winds sweep the surface of the ground continuously.

Continuing eastwards we reached Kyekye on 4th September, *viâ* the Pu-La (a pass on the boundary between the Tibetan provinces of Ü and Takpo, and also on the watershed between the Tsangpo and the Subansiri River). Here we saw numbers of Tibetan gazelle, of which I shot one. On awaking the following morning we found that the box containing our store of money had been stolen from our tent during the night, and that three of our own coolies were missing. Though we sent letters to all the neighbouring "dzongpens," we never discovered any trace of the three culprits, or of our missing property. We also wrote to the head of the Kashmiri community in Tsetang, Qazi 'Ata ulla, informing him of our plight. This man very obligingly agreed to cash us a cheque on Calcutta, himself travelling all the way to Lhontse dzong with the money.

Meanwhile we continued our journey down the Char River nearly to Sanga Chöling; turning up a side valley eight miles west of this place and crossing the Kamba Pass, we found ourselves again in the Tsangpo drainage, at the head of the Trulung River. Following down the western and up the eastern branch of this river we crossed the Kongmo Pass (17,520 feet) into the head-waters of the Tsari River, another branch of the Subansiri. This valley which we followed as far as Migyitün, is remarkable for its very heavy rainfall, which is reflected in the denseness of the jungle growth on the hillsides; in this respect it differs widely from the other Tibetan head-waters of the Subansiri, namely, the Char, Nye, and Loro or Chayal Rivers, all of

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which, down to the point at which they pierce the main Himalayan axis, traverse dry arid valleys.

The Tsari valley contains the sacred shrine of Chikchar, and the entire district is considered so holy that not only is no shooting or killing of animals allowed therein, but from the Kongmo Pass downwards the ground is not allowed to be broken by plough, or tilled in any way. Food is correspondingly expensive. The Buddhist religion, of course, forbids the taking of life in any form. The Tibetans, however, only apply this principle to wild animals, though they ordinarily made no objection to our shooting as much wild game as we wished for food or for sport.

Below Migyitün the road is only used by the semi-savage tribesmen from the southern slopes of the Himalayas, who come up to trade in salt, in the cold weather. At the time of our visit, the bridges had been carried away in flood and the road was impassable.

On the return journey, Bailey followed the route of the Tsari pilgrimage, starting from Chikchar, while I proceeded *viâ* the Cha Pass (16,610 feet) direct to Sanga Chöling. Here I had a most hospitable reception, and halted a day to visit the large and well-appointed monastery. I then completed the survey of the remainder of the Char River down to the point where it enters the gorge of the Himalaya at Lung. The last inhabited Tibetan village is Drü, below which the scenery changes with startling abruptness. On rounding a bend in the valley, at the deserted village of Raprang, the placid river suddenly becomes a foaming rapid with a fall of 300 feet in a mile, while the bare Tibetan hillsides are succeeded in the course of a few miles by the dark leech-infested jungles of the Himalaya.

I returned to meet Bailey at Charmé whence we crossed the Le Pass to Nyerong on the Nye River. Eight miles below Nyerong the Nye River unites with the Loro River to form the Chayul, which in turn joins the Char River at the Lung gorge to form the main branch of the Subansiri. We followed the Chayul down the extreme Tibetan village of Drötang, below which there was said to be uninhabited country for five or six marches before the first "Lopa" village is reached. "Lopa" is the Tibetan name for the semi-savage inhabitants of the Subansiri valley on the south side of the main Himalayan range. These "Lopas" come up the valley in large numbers to trade when the road is open during the cold weather, but no Tibetan ever visits the "Lopa" country, so that it is not easy to obtain information from the Tibetan side. At the time of our visit the valley road was closed and a large stretch of the middle course of the Subansiri had still perforce to remain unsurveyed. The "Lopas" will not accept money, and the trading is all done by barter, madder dye being exchanged for salt. A curious custom prevails of adulterating the salt with large quantities of a kind of dry moss which grows on the

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Tibetan uplands, three parts of moss being mixed with one of salt before exchanging with the "Lopas." We failed to ascertain the precise cause or origin of this custom; it is not apparently done merely with the object of cheating the "Lopas," since the latter seem to be fully aware of the practice. One man informed us that were it not for the moss, the salt being "hygroscopic" would liquify and escape from the sacks in the damp climate of the "Lopa" country.

Returning to Chayul dzong, we followed up the Loro Valley to Trashi Tongmé. Here I recognized a group of triangulated snow peaks to the S.E., and was able to check my position by the method of "latitude and azimuth."

Two streams, the Loro Karpo and the Loro Nakpo (White Loro and Black Loro) here unite. We ascended the valley of the latter, and on 2nd October crossed a high pass, the Pen La (17,330 feet) into the head of the Seti Chu, in the drainage system of the Manas. The Seti Valley is uninhabited, and the river cuts through the Himalayan range in an impassable gorge. The road after rounding a spur crosses the main Himalayan axis by the Tulung Pass (17,250 feet), and follows a steep narrow valley down to the curious twin villages of Nyuri and Dyuri which together form the remote little district of Mago, situated in the heart of the mountains. Immediately below Mago the river enters a gorge down which there is no communication, and the only other road is one over the Chera Pass. From the top of this pass two roads diverge, one going westwards to Tawang, and one which we followed crossing the Tse Pass (15,550 feet) into a branch of the Dirang River—itself a tributary of the Bharoli River of Assam. After crossing the Pöshing Pass, the road descends a spur to the last Tibetan village of Lagam. From our camp below the Pöshing La, the plains of Assam were clearly visible in the early morning, but clouds soon obscured the landscape.

We were now amongst the Bhutanese again, and although the heat of the low-lying "Mönba" valleys was somewhat enervating, yet the verdant hill-sides had neatly cultivated fields, forming a pleasant contrast to the barren landscapes of Tibet. Millet, buckwheat, tobacco, chillies, and maize appeared to be the chief crops. The two latter were being gathered as we passed, and the red chillies spread out to dry on the roofs of the houses formed a pleasing dash of colour. The Indian madder vine (*rubia cordifolia*) grows wild in this country, and the madder is exported in enormous quantities to Tibet, for dyeing the gowns of the monks.

Three marches from Lagam brought us to Dirang dzong, where we were again on Nain Singh's old route, which we followed over the Se Pass (13,940 feet) to Tawang. The weather at this period was execrable, and I was very glad to have Nain Singh's fixed position of Tawang from which to start my traverse afresh.

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All this time we had been entirely subsisting on the 70 rupees or so which we had in our belts and pockets when our money was stolen in Kyekye six weeks previously; and although we had sent two of our own servants to receive the money from Qazi 'Ata Ulla, we had not been able to arrange any place for our servants to join us again. So, although we had now accomplished our mission, namely, the exploration of the Frontier from Pemakö to Tawang, we had to return once more to Tibet to pick up our servants and money.

Leaving Tawang on October 19th, we avoided Nain Singh's route, and descended the valley of the Tawang Chu, as far as the confluence of the Nyamjang. The latter is an important river 90 miles in length, which rises in Tibet and cuts through the Himalayan range in latitude 28° 0′—28° 5′, but it has not been shown on any previous map. The villages are Bhutanese as far as Trimo, at which point we left the valley and crossed the Pö Pass (14,900 feet) to Tsöna. Here we found our two servants waiting with the money. We were now (October 23rd) once more on the Tibetan "Chang tang," and the cold was intense; but we wished to complete our survey of the waters of the Laro Karpo and the Nye Rivers before returning, so having expended our money in "Chubas" (thick blanket coats) for our servants and blankets for ourselves, we set out on the road to Trashi Tongmé. Bailey travelled *viâ* the Lagor Pass to Lhöntse, thence making an excursion down the Nye River. I halted a day at Loro to follow a herd of *ovis ammon*, out of which I got two fine males, which kept us and our coolies supplied with mutton for the rest of our journey. I rejoined Bailey at Lhöntse, travelling *viâ* the Gyandro Pass.

Below Lhöntse the Nye River flows through a narrow gorge, but the upper portion of the valley consists of a wide stony plain, or "pamir," upwards of a mile in width and containing numerous fields and scattered homesteads.

On the 31st October we crossed our last high pass, the Hor La (17,680 feet), into the head-waters of the Nyamjang Chu. The western descent from this pass is extremely narrow and steep; below Gyao, however, the valley widens and the river flows in a wide, shingly bed as far as Dongkar dzong, where it again enters a gorge. Opposite the village of Rong the slates and shales of Tibet give place to Himalayan granite and limestone, and jungle and pine trees begin to appear on the hillsides. The main Himalayan axis appears to be crossed between this village and the extreme Tibetan village of Rong.

At Trimo we were on our previous road, which we followed as far as the confluence of the Nyamjang and Tawang Rivers.

Just below this we crossed the Bhutanese frontier, and on 9th November reached Trashigang, where we found a "devil-dance"

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in progress, and were hospitably entertained by the Bhutanese dzongpen. Here my survey ended, as the country between Trashigang and the Plains of Assam is already included in the trans-frontier series of the Indian survey maps. Owing to delays in collecting transport much of the last portion of our journey was accomplished by moonlight, so that surveying would in any case have been impracticable. Travelling *viâ* Diwangiri, we reached Rangiya junction on the Eastern Bengal State Railway at 2 a.m. on the 15th November after a journey estimated at 1,680 miles, through country which, with three minor 18th century exceptions referred to below, has never before been seen by any European.

PREVIOUS EXPLORATION IN S.E. TIBET; VINDICATION OF KINTHUP; SUMMARY OF GEOGRAPHICAL RESULTS OF OUR TRIP; CONCLUSION.

The valley of the Po-Tsangpo has not been visited by any previous explorer, and no explorer except Kinthup has previously traversed the district of Pemakö. Further westward, however, the country is better known.

The earliest record of travel in the province of Takpo appears to be that of the Italian Friars who established the Capuchin Mission at Lhasa in the year 1708. Two members of this mission diverged eastwards, crossed the Yarlung Valley, and eventually penetrated into the province of Takpo, east of Tsetang. Thence they appear to have travelled N.W. to join their brethren at Lhasa. Ten years later we hear of a branch of the Mission being opened at Drong-Nye in Takpo, which is described as near the borders of East Bhutan, about 14 days' journey to the S.E. of Lhasa* This is probably the village of Trong-Nye on the Tsangpo just north of Guru Namgye Dzong. The Capuchin Mission finally collapsed in the year 1745. The only other European traveller in these parts was the Jesuit, Ippolito Desideri, who was commissioned to visit and report on the Capuchin Settlement at Lhasa. His sojourn in Tibet extended from 1716–1721, during which time he made numerous excursions to places S. and S E. of Lhasa, visiting Samye, Tsetang and the Yalung Valley.

From the date of the final closing of the Capuchin Mission, no further additions were made to our knowledge of this region of Tibet until the era of the Survey of India Native explorers in the decade 1874–84 The first explorer to penetrate this country was late Nain Singh, C.I.E., then known as the Pandit, who reached Lhasa, on his second and last famous journey across Tibet, on the 18th November, 1874. Thence striking S.E. to Samye he followed the Tsangpo to Tsetang. Continuing up the Yarlung Valley over the Yartö-Tra and

* "The Exploration of Tibet: Its History and Particulars from 1623 to 1904" by Graham Sandberg, B.A., pp. 31—40.

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Karkang passes into the Sikung district, which is drained by the Nye Chu, he crossed the highly elevated plains of Tengsho and Tsöna, and reached Tawang, where he was detained for some three months. Escaping in February, 1875, the Pandit crossed the Se Pass and travelling *via* Dirang dzong reached Odalgiri in the Plains of Assam on March 1st, 1875.

In December, 1875, the road from Tsetang to Tawang was traversed by explorer " L," who had followed the course of the Tsangpo eastwards from Shigatse, and who wished to follow Nain Singh's route to Assam. At Tawang, however, permission to proceed was refused, and the party after having been taken before the authorities, were imprisoned for a month in the public flour mill. Subsequently three mounted soldiers were told off to escort " L " back to Lhasa. Fortunately, some informality in the documents carried by the guard induced an intermediate official, through whose hands he passed *en route*, to release him, and he was able to make his way back to Shigatse.

In 1878, Capt. Harman, R.E., trained a Sikkimese monk, Nem Singh, and sent him to Tsetang with orders to survey the eastward course of the Tsangpo. Owing to bad weather, Nem Singh had to be despatched before his training was complete; while owing to fear of robbers for whom the province of Takpo was in those days notorious, he hurried over much of his work at undue speed, keeping his record on scraps of paper which were not properly entered in the Field Book. His astronomical observations were also vitiated by an error in his dates. He finally reached the village of Gyala, near Pemakö-Chung, to which he assigned a height of 8,000 feet and a longitude of 94°. Here his traverse ended " in air."

The next explorer is Kinthup, whose work has already been referred to. Kinthup's description of the country, given from memory after his return, is in general quite accurate; referring, however, to Pemakö-Chung, the following erroneous statement is attributed to him in his report :—" The Tsangpo is two chains distant from the Monastery, and about two miles off it falls over a cliff called Sinji-Chogyal from a height of about 150 feet. There is a big lake at the foot of the falls where rainbows are always observable." Actually, the falls near Pemakö-Chung, to which the Tibetans have not given a name, are only some 30 feet in height, though it is true that a rainbow is visible on sunny days in the spray which is thrown up in immense clouds. On the other hand, falls called Shingche Chogye of approximately 150 feet, do actually exist on a small side stream, which joins the Tsangpo on the N. bank opposite Gyala. It would seem that in the course of dictation and translation of Kinthup's narrative, the accounts have been confused of the two separate falls.

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After our return to India, Bailey found that Kinthup was still alive, living in retirement in his native Sikkim. He was summoned to Simla in May, 1914, where Bailey questioned the old man regarding his assertion about the falls. His statement then agreed with our observations. As the result of our favourable reports on his work, Kinthup received an additional reward of Rs.1000 from the Government of India, together with a parchment certificate of honour from the Surveyor-General. He died on 3rd November, 1919.

The only remaining travellers who call for mention are two members of the Bengal Educational Service. Sarat Chandra Das in his interesting book* has given a graphic description of the Yarlung Valley, which he visited on his return from Lhasa in November, 1882. Lama Ugyen Gyatso, who had previously accompanied Sarat Chandra Das to Tibet, was again dispatched to Tibet on special duty by the Director of Public Instruction, Bengal, in June, 1883. Travelling *viâ* Gyantse, and the northern shore of the Trigu Lake, he reached the Yarlung Valley, whence he returned along the northern bank of the Tsangpo to Samye and Lhasa. His narrative, like that of Sarat Chandra Das, does not give much new geographical information, but forms an interesting record of Tibetan social and religious customs concerning which he has many quaint stories. He particularly dwells on the freedom accorded to women in Tibet ; finally laying down the maxim, as the result of much varied experience, that a fair complexion amongst the gentle sex always indicates true kindness of heart.

A brief summary of the principal geographical results of our expedition may not be amiss. Climatic conditions militated against the discovery of more than a very few new snow peaks—indeed the only ones whose positions I was able accurately to determine were those of the Gyala Peri group on the N. bank of the Tsangpo, at the great bend opposite Namcha Barwa. Gyala Peri itself is 23,460 feet in height ; while an eastern satellite of Gyala Peri, and the peak of Sengdam Pu at the opposite end of the same range are both over 20,000 feet. The magnificent peaks of Namcha Barwa (25,445 feet) had of course been previously fixed from the south, both by the Abor Survey Party and by my own observations from the Mishmi Hills. Our examination of the Tsangpo gorge on its northern flanks enabled us definitely to prove this to be another striking example of the extraordinary feature of Himalayan geography, noted by Colonel Sir S. G. Burrard† namely, that when a Tibetan river cuts

* "Journey to Lhasa and Central Tibet," by Sarat Chandra Das, C.I.E., pp. 297—307.

† "A Sketch of the Geography and Geology of the Himalaya Mountains and Tibet," by Colonel Sir S. G. Burrard, K.C.S.I., F.R.S., R.E., and H. H. Hayden, B.A., F.G.S. Part III., pp. 160—186.

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through the Himalayan range, it almost invariably selects the very highest portion of the range through which to pierce its gorge. We did not succeed in throwing much light on the course of the main Himalayan range east of Namcha Barwa. There is a very sharp range of snowy mountains in the curious loop of the Po-Tsangpo ; N.W. of the Sü Pass, but whether this is a true continuation of the Himalayan chain further investigation can alone decide.

Our map shows one glacier flowing southwards from the Gyala Peri range, and five flowing N. and W. from Namcha Barwa, while we were informed that a sixth glacier occupied the upper portion of the Pupa Rong Valley on its south flank. These glaciers all bear evidence of slow, but prolonged retreat. The Trilung glacier, which we visited, at present ends some two miles short of the Tsangpo ; the height at the foot of the " Chinese wall " being 11,400 feet. Pines of thirty years' growth were to be found a quarter of a mile below the present limit of the ice. The Sanglung glacier, which is the largest of the group, descends to within one mile of the Tsangpo, the height at the foot of the snout being only 9,030 feet.

The Po-Tsangpo and Yigrong had not been previously visited by travellers ; we were also able to obtain for the first time a fairly complete picture of the courses of the various Tibetan headwaters of the Subansiri, viz. : the Tsari, Char, Nye, and Loro Rivers, down to the points at which they pierce the Himalayan chain ; while further west we found in the Nyamjang Chu, a new and important Tibetan tributary of the Manas River, hitherto unmapped. It is noteworthy that the falls of 30 feet on the Tsangpo at Pemakö-Chung are higher than anything hitherto recorded on the big rivers of Tibet and the Himalaya ; indeed, the only other known instance of falls on a large Himalayan river is a 20-feet drop on the Indus near Bunji.

Hypsometric observations were taken on twelve passes of over 15,000 in height, while the approximate positions of numerous other passes have been indicated on the map from local information.

As has been previously remarked, I was only able in general to use the most rough and ready methods of reconnaissance survey. The system adopted was merely that of setting the plane-table by compass and estimating distances by time. As a check on the work, 20 observations were taken for latitude and seven azimuths. The instrument carried was a 3-inch theodolite by Casella, which screwed on to a light stand when required for taking astronomical observations. The same little instrument was also used, resting on the plane-table, as a clinometer, thus avoiding the necessity of carrying the latter instrument. My survey was on the scale of 8 miles to one inch. We took great care in regard to the orthography of place-names occurring on the map ; these were almost invariably spelled for us in the vernacular by dzongpens, or other local officials under Bailey's super-

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vision. Some 500 names are believed to be new, while in numerous instances the spelling of old names has been revised. Bailey brought back a small but interesting collection of mammals, birds, and butterflies, each of which were found on examination to contain new species.

It only remains to add that throughout our journey we everywhere met with the utmost courtesy and hospitality from the Tibetans. We carried no food with us, and were entirely dependent on the goodwill of the Tibetans for supplies, lodging, and transport.

I cannot conclude without placing on record how largely the success of our undertaking was due to Bailey's energy and resource. To him was due the original idea of the expedition, and but for his thorough knowledge of the language and customs of the country, and his almost uncanny skill in winning the goodwill of the local officials it could never have been successfully carried out.

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Part of
NORTH-EASTERN FRONTIER
AND
TIBET
showing the routes of
CAPTAINS MORSHEAD and BAILEY
1913.

Scale 1:1,000,000 or 1 Inch = 15·78 Stat. Miles

10 5 0 10 20 30 40 50

Symbols and Abbreviations.

Author's Route
Monastery (Gompa) ... Ga.
Fort, or Headqtrs of Local Gov't. Official (Dzong) ... Dz
Mountain Pass (La) ... x
Rest House ... R.H
Heights in Feet.

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NORTH-EASTERN FRONTIER AND TIBET
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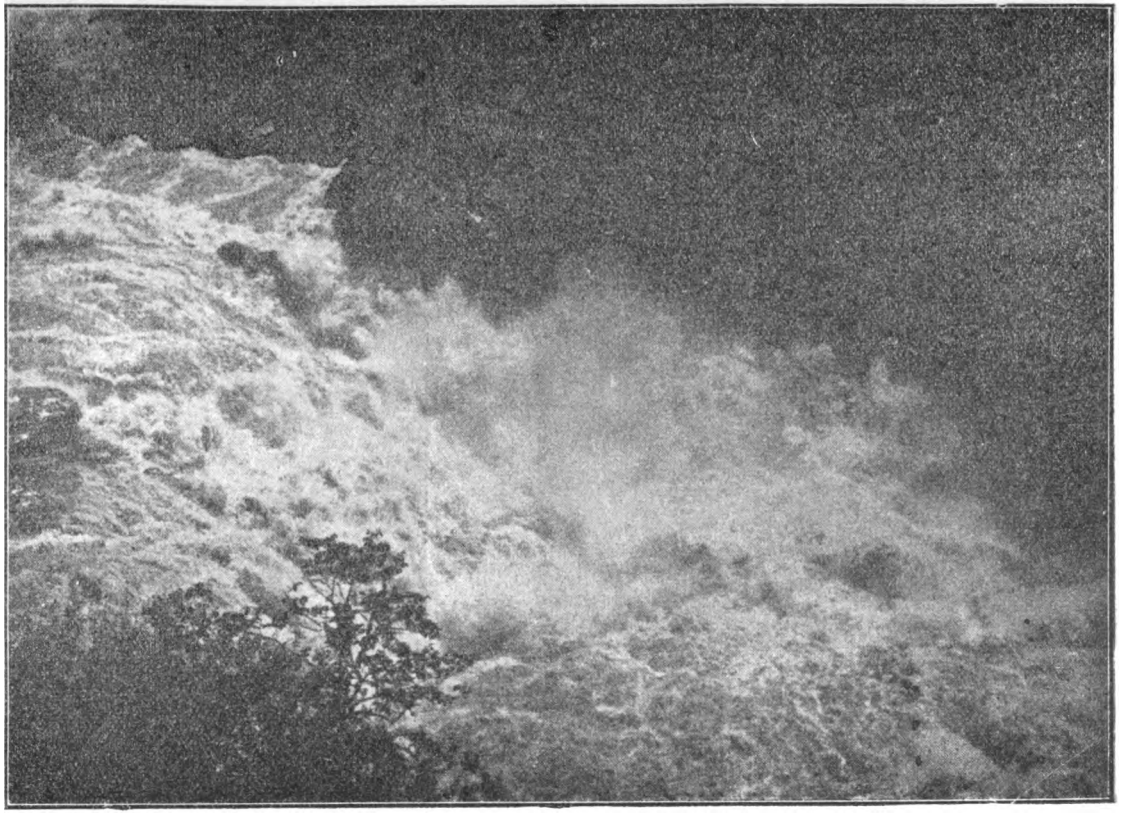

The TSANGPO falls, at PEMAKO CHUNG.

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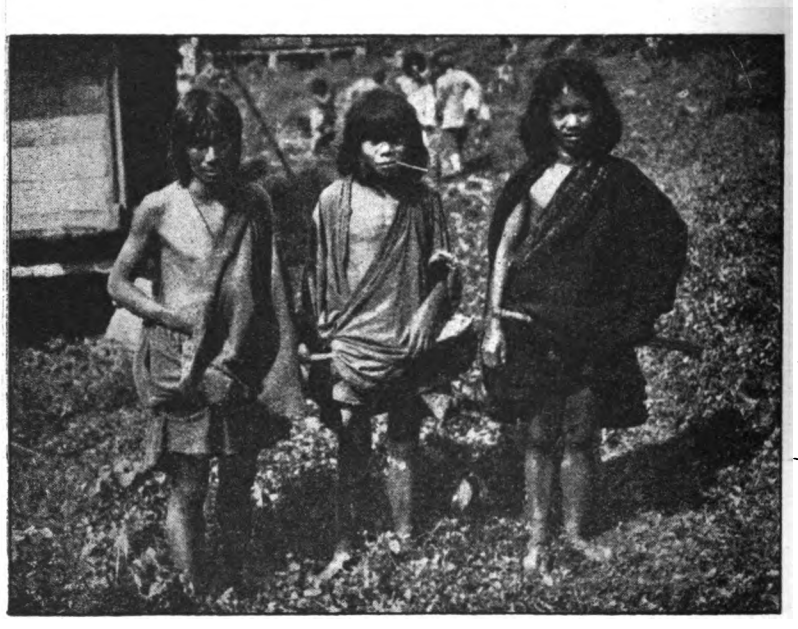
A Poba of Showa



Group of Mönbas in Penakö.

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The TSANGPO falls, from water-level.

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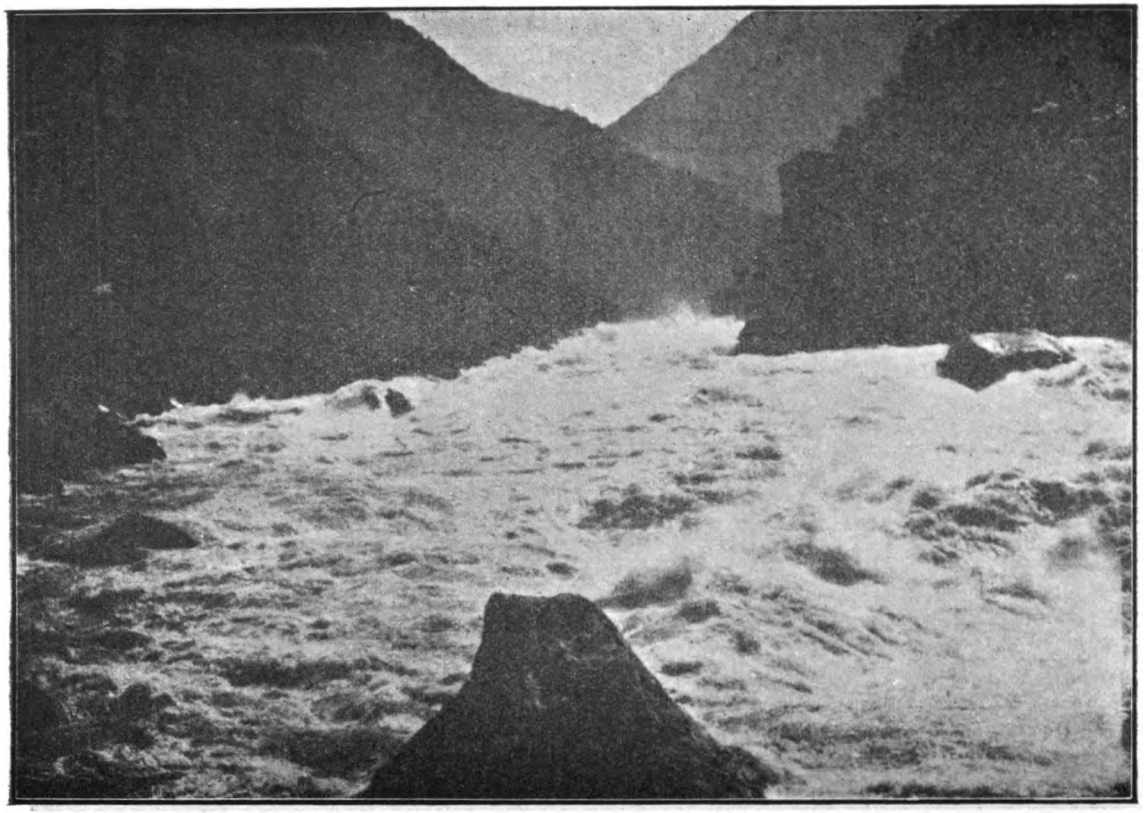

Rapids on the TSANGPO, looking upstream from NYUKSANG.

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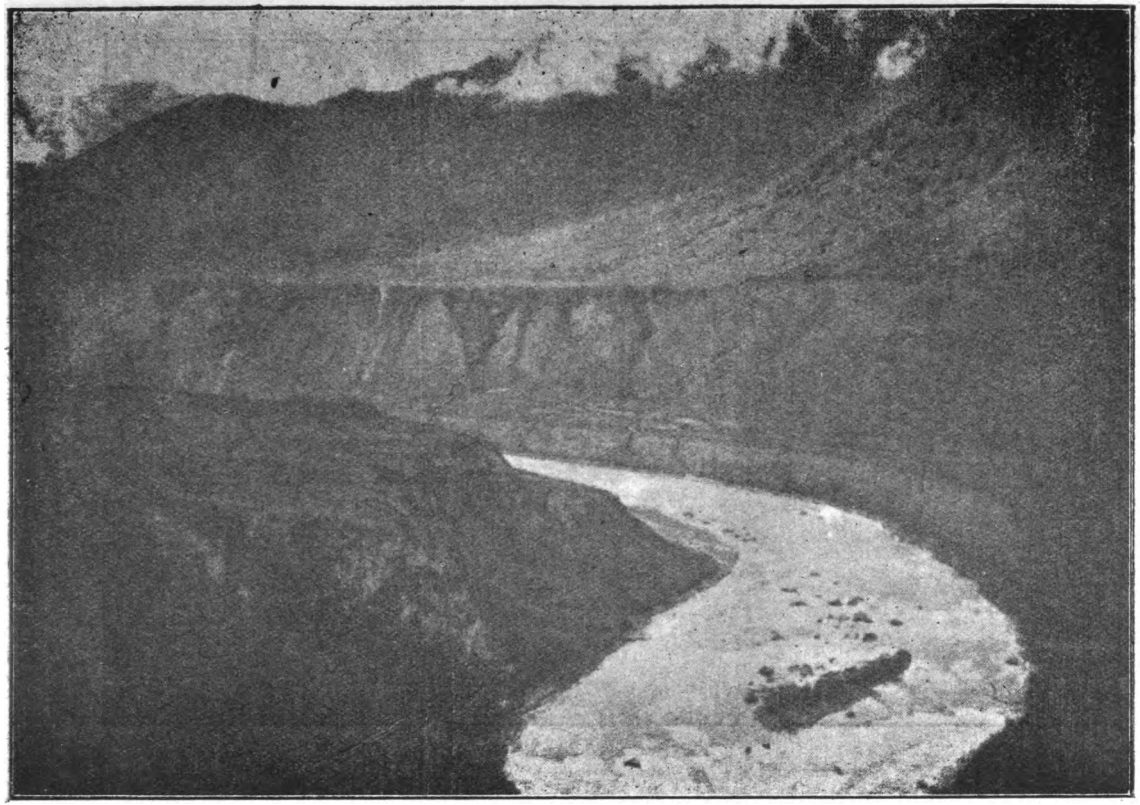

View upstream from TSANGPO right bank near KYIKAR.

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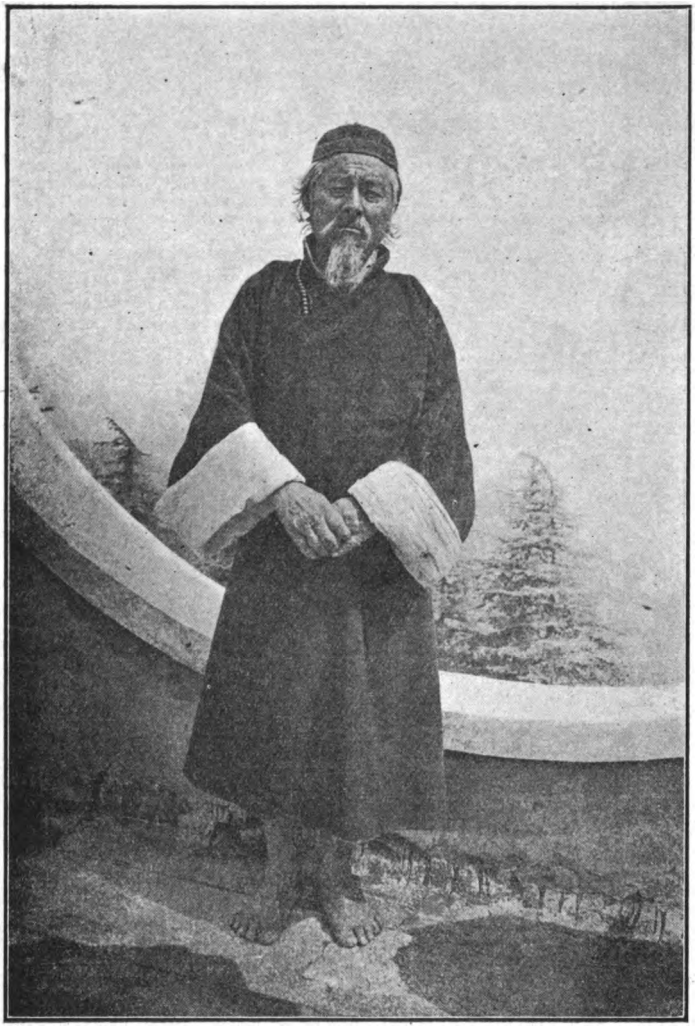

Explorer KINTHUP, who first traced the course of the TSANGPO below PEMAKO CHUNG.

From a photo by Lieut. G. Burrard, R.F.A., May 1914.

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SOUND RANGING.

The following article from *The Times* of the 15th November, is reproduced by the courtesy of the Editor.

In connexion with the forthcoming decoration by the French Academy of the Abbé Rousselot for his original invention of the method of fixing the position of enemy guns by "sound-ranging," the following is an authoritative account of the early history of sound-ranging on the Western Front, and of the part played by the British in its development :—

The earliest experiments of which we have knowledge were those conducted by Professor Nordmann, of the Paris Observatory. He conceived the idea of sound-ranging at the front, and began experiments in Paris in September, 1914. His first plan was to work on a measured base with three men, each with a stop watch, who would record the instant the sound reached them ; but he also foresaw the use of microphones and automatic means of registration. In connexion with the latter, he consulted Mr. Lucien Bull, Sub-Director of the Institute Marey, who is a British subject resident in Paris. Various experiments were carried out, which developed into the Bull system, which was officially adopted by the British and later by the American Armies, and the T.M. system, officially adopted by the French Army. Other systems were developed independently, notably the Dufour and Cotton-Weiss, and were employed on the French front.

The subject had already attracted interest in the British Army, and a special committee was sent to the French front to investigate the possibilities of sound-ranging. This committee recommended the adoption of the Bull system, and a set of apparatus was bought and was delivered in October, 1915.

In the meantime the War Office had secured the services of Lieutenant (now Major) W. L. Bragg (now Professor of Physics, Manchester University) to form the first sound-ranging section and develop the method for the British Army. Bragg collected a small staff of physicists and carried on the work of the first section in the face of considerable difficulties due to lack of *personnel*, unsuitable apparatus, and ignorance of the various complicated factors which affect the subject. Though the French were ahead of us in initiating the system, the science, at the time that we began practical operations, was in a crude state, and there was much that was unknown. A good deal of original investigation was, therefore, required in order to make sound-ranging of real practical value.

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PROBLEMS OF WIND AND TEMPERATURE.

The first problem to be attacked was that of the microphone, as the type then in use had many defects. Bragg, with his assistants, set to work on this, the line which experiment should take being indicated by the investigations of a French physicist, Professor Esclangon. In June, 1916, Lieutenant (now Major) Tucker invented the microphone which bears his name. This microphone was a very great advance on anything previously known, and from the date of its introduction British sound-ranging may be said to have ranked as an exact method of locating guns.

The next question was that of corrections for wind and temperature on which information was still vague and inaccurate. The formation of " wind sections " and the able investigations of Lieutenant Gray resulted in the establishment of accurate formulæ for the application of these corrections.

Other improvements in method were introduced, among the most important being the adoption of microphone bases of regular form. The advantage of this had been foreseen by Bull, and the final adoption on our part was due mainly to the advocacy of Bragg. Great attention was paid also to the training of sound-ranging sections to fit them for employment in moving warfare.

While the debt due to the French for their initiative must be acknowledged, it will be seen that, from the time that we took up sound-ranging, British scientists carried on independent investigations, and developed the method to a high degree of perfection. Opinions differ on certain technical points, but it was generally acknowledged that the British system, with its combination of the Tucker microphone and the Bull recording apparatus, was second to none for efficiency and accuracy. The Americans, when they took the field, adopted, after careful investigation, the British method and apparatus in their entirety.

Sound-ranging was not the only method of fixing enemy guns which was evolved during the war. The other principal method was that of " flash-spotting." These two systems (which may be called methods of precision, in comparison with the rapid, but less accurate, method of reporting by map position from an aeroplane or balloon) are complementary, and neither is of full utility without the other. Both methods were developed entirely by officers of the Field Survey Battalions, Royal Engineers.

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BOOKS ON CIVIL ENGINEERING.

The following is a revised list of books on Civil Engineering which are recommended to Officers who wish to improve their knowledge in various branches of this subject.

Should any officer require further information on any of these books or with regard to any branch which is not fully met by any of them he should write direct to the Secretary, R.E.I., Chatham, stating as fully as necessary what his requirements are, and every endeavour will be made to supply or procure the information.

The latest editions of these books will be kept in the R.E. Library, Horse Guards, S.W.1.

1. APPLIED MECHANICS.

CALCULUS FOR ENGINEERS.—By Prof. Perry. Published by Edward Arnold. 7/6.

A most useful and interesting book, giving progressive examples of the practical application of the Calculus to Engineering and Electrical problems.

Unlike most other treatises on the Calculus, this book is essentially practical from beginning to end.

THE STRENGTH AND ELASTICITY OF STRUCTURAL MEMBERS.—By R. J. Woods M. Inst. C.E. Published by Edward Arnold, London. 2nd edition; 1 vol.; 8vo. 1906. 10/6.

Chapter I., Graphic Statics. Chapter II., Stress and Strain. Chapter III., Stress-Strain Diagrams, Working Stress, Resilience. Chapter IV., Compound Stresses Chapter V., Bending Moments and Shearing Forces. Chapter VI., Moments of Inertia. Chapter VII., Girders. Chapter VIII., Deflections. Chapter IX., Combined Stress, Non-Axial Stress, Stress at a Plane Joint, Masonry Structures. Chapter X., Columns and Struts. Chapter XI., Riveted Joints. Chapter XII., Continuous Girders. Chapter XIII., Cantilever Bridges, Suspension Bridges, Arched Ribs. Chapter XIV., Torsio.

This book was originally written as a series of lectures for students at the Royal Indian Engineering College, Coopers' Hill. It is a clearly written elementary text book.

THE THEORY OF STRUCTURES.—By R. J. Woods, M. Inst. C.E. Published by Edward Arnold, London. 1 vol.; 8vo.; 1909. 10/6.

Chapter I., Compound and Principal Stresses. Chapter II., Earth Pressure. Chapter III., Stresses due to Eccentric Loads. Chapter IV., Working Stresses. Stresses in Girders with Parallel Chords by Method of Co-efficients. Chapter V., Girders with Parallel Chords, General Method. Chapter VI., Parabolic Girders. Chapter VII., Curved Girders, not Parabolic. Chapter VIII., Wind Pressure, Portal Bracing, High Steel Trestles. Chapter IX., Continuous Girders. Chapter X., Cantilever Girders, Suspension and Stiffening Girders. Chapter XI., Riveted Joints. Chapter XII., Plate Girders. Chapter XIII., Columns and Struts. Chapter XIV., Arched Ribs and Braced Arches. Chapter XV., Reinforced Concrete.

This book is a continuation of "The Strength and Elasticity of Structural Members" by the same author. It contains several worked out examples but no drawings of actual work.

THE THEORY AND DESIGN OF STRUCTURES.—By E. S. Andrews, Lecturer at the Goldsmiths' College, New Cross. Published by Chapman and Hall, London. 1 vol.; 8vo.; 1908. 9/-.

Chapter I., Stress, Strain, and Elasticity. Chapter II., Principles of Design, Working Stress, Wind Pressure. Chapter III., Forces, Areas, Moments. Chapter IV., Riveted Joints. Chapter V., Bending Moments and Shearing Forces. Chapter VI., Stresses in Beams. Chapter VII., Rolling Loads. Chapter VIII., Deflection. Chapter IX., Fixed and Continuous Beams. Chapter X., Shearing Stress in Beams. Chapter XI., Framed Structures. Chapter XII., Columns and Struts. Chapter

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XIII., Suspension Bridges and Arches. Chapter XIV., Masonry Structures. Chapter XV., Reinforced Concrete. Chapter XVI., Design of Steelwork in Buildings. Chapter XVII., Design of Roofs. Chapter XVIII., Design of Bridges and Girders.

This book covers the usual college course, and is good of its kind, but only touches lightly on questions of design. The diagrams and general presentation are good.

DEFLECTIONS AND STATICALLY INDETERMINATE STRESSES.—By C. W. Hudson. Published by Chapman and Hall. Price 19/-.

Treats of the deflections of solid and built up beams and cantilevers by the method of internal work.

The determination of stresses in redundant members by the use of Castiglioni's Theorems.

Well illustrated by Examples.

2. MATERIALS.

JOHNSONS' MATERIALS OF CONSTRUCTION.—Rewritten and edited by F. E. Turneaure. 1919. 5th edition. 33/-. Published by John Wiley and Sons, New York (Chapman and Hall, London).

The authors aim to provide essential information concerning the sources and manufacture of the principal Materials of Construction; to give carefully selected data covering the more important mechanical and physical Properties and the influence of various factors upon these properties; to show the causes of defects and variations and how they may be discovered; to furnish an acquaintance with the technique of testing materials; and to present some of the more general uses of the materials.

Chapter I. gives a synopsis of the Principles of Mechanics of Materials. Chapters II. and III. deal with Machines and Appliances for Testing, the Technique of Testing and the Utility of the various Tests. Chapters IV.—VI. consider the Characteristics, Methods of Identification, Properties and Uses of the more Important Woods, also Causes of Decay and Means of Preservation. Chapter VII. treats of the Important Stones, their Constitution, Durability, and Properties. Chapter VIII. covers the Manufacture and Testing of Structural Clay Products, together with their Mechanical Properties and Uses. Chapters IX.—XII. deal with the Nature, Manufacture, Methods of Testing and Properties of Hydraulic Cements, Limes and Plasters. Chapters XIII.—XV. fully describe Methods of Making Mortar, Concrete, and Concrete Products, also the properties and Uses of these Materials. Chapter XVI. provides a brief summary of the Utility of the Principal Metals, their Ores, and Fundamental Considerations governing their Extraction. Chapters XVII.—XIX. treat of the Reduction of Iron from its Ores and subsequent purification and Fabrication. Chapters XX. and XXI. deal with the Formation and Structure of Alloys in general, and the Constitution of Iron and Steel. Chapters XXII.—XXIV. are devoted to a discussion of the Properties and Uses of Wrought Iron, Steel and Alloy Steels. Chapter XXV. takes up the Manufacture, Moulding, Constitution and Properties of Cast Iron and Malleable Cast Iron. Chapter XXVI. treats of the Production, Properties and Uses of Copper, Zinc, Aluminium, Lead, Tin, Nickel and their Alloys. Chapters XXVII.—XXIX. cover the effects of Temperature on Metals, the Causes and Effects of Fatigue, and the Corrosion and Protection of Metals.

The book is thoroughly up to date and contains much valuable information on the latest processes, tests and specifications applied in the U.S.A., and is strongly recommended for *study* and practical reference.

THE STRENGTH OF MATERIALS.—By J. A. Ewing, F.R.S., M. Inst. C.E., etc. Cambridge University Press. 12/6.

Chapter I., Stress and Strain. Chapter II., Relation between the Elastic Constants. Chapter III., Ultimate Strength and Non-elastic Strain. Chapter IV., Testing of Materials. Chapter V., Uniform and Uniformly Varying Distributions of Stress. Chapter VI., Stress in Beams. Chapter VII., Deflection of Beams. Chapter VIII., Frames. Chapter IX., Struts and Columns. Chapter X., Torsion of Shafts. Chapter XI., Shells and Thick Cylinders. Chapter XII., Hanging Chains and Arched Ribs.

3. BUILDING CONSTRUCTION.

BUILDING CONSTRUCTION—ELEMENTARY COURSE.—By Chas. F. Mitchell, M.S.A., etc., and Geo. A. Mitchell, A.R.I.B.A. 6/6. Sub-title, "A Text Book on the Principles and Details of Modern Construction."

The ninth edition, published in 1919, contains elementary instruction in all the Trades employed in Building, with the Board of Education Syllabus the scope of which it is intended to fulfil.

BUILDING CONSTRUCTION—ADVANCED COURSE.—By the same authors. 11/-. Also in its ninth edition (1919), with the sub-title "A Text Book on the Principles and Details of Modern Construction for the use of Students and practical men."

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Continues the instruction in the Trades and meets the requirements of the Advanced Syllabus of the Board of Education and other Examining Bodies; it also reviews Building Materials and summarises Building Regulations, Theory of Construction, and Sanitation.

Both volumes published by B. T. Batsford, Ltd., 94, High Holborn, W.C.

BUILDING CONSTRUCTION.—In 2 vols., Edited by F. M. Simpson, F.R.I.B.A. 12/-. each.

The various subjects being undertaken by:

Beresford Pite, F.R.I.B.A. (Brickwork)
Frank T. Baggallay, F.R.I.B.A. (Stonework)
H. D. Searles-Wood, F.R.I.B.A. (Carpentry)
E. Sprague, A.M.I.C.E. (Theory and Steel Construction)

in volume I. and by

J. H. Markham, A.R.I.B.A., Edwin Gunn, A.R.I.B.A., Alan G. James, H. A. Satchell, F.R.I.B.A., F. M. Simpson, F.R.I.B.A., and J. D. Grace, the subjects comprising Reinforced Concrete, Roof Covering, External Plumbing, Glazing, Timber, Joinery, Plastering, and Painting and Decoration, in the same order of authorship.

These volumes form part of the "Architects Library" published by Longmans, Green and Co., 39, Paternoster Row.

4. HOUSE PLANNING AND ARCHITECTURE.

THE CHEAP COTTAGE AND SMALL HOUSE.—By Gordon Allen (late R.E.), F.R.I.B.A., with the Sub-title "A Manual of Economical Building." Ninth edition, revised and enlarged. 1919. Published by B. T. Batsford, Ltd. Price 7/6.

Is intended to deal with the present situation and is illustrated with many examples of recent attempts to solve the problem of providing houses for the manual worker which shall be not only economical both in first outlay and subsequent upkeep as well as small houses of more ambitious character designed by the author in the course of practice.

From the chapter headings it will be seen that the book treats of economy in planning, as well as in treatment of elevations and the supply of External Services, shews some of the effects of legislation and helps in the selection of suitable materials.

ESSENTIALS IN ARCHITECTURE.—By John Belcher, A.R.A., Past P.R.I.B.A. "An Analysis of the Principles and Quantities to be looked for in Buildings." Published by B. T. Batsford, Ltd. Price 7/6.

The chapters deal with the Principles, Quantities, Factors and Materials in Architecture in a simple and lucid manner and the illustrations greatly add to this lucidity, the buildings illustrated being used to deduce results by analysis.

ARCHITECTURAL COMPOSITION.—By J. B. Robinson, Member of the American Institute of Architects.

This book also was first published in America in 1907, and subsequently by Batsfords in 1908, and there is at least one more recent edition which it is believed is also out of print, another being expected shortly.

The subject of Architectural Design is treated in relation to other arts in order to deduce principles which presumably must be basic and common to all.

The copious illustrations are largely of a diagrammatic nature intended to show whence these abstract principles are revived and how they affect Architectural Design.

5. HEATING BUILDINGS, HOT WATER SUPPLY AND VENTILATION.

HOT WATER SUPPLY.—By F. Dye. Published by E. and F. N. Spon. 1912. Price 3/-.

Chapter I., A brief explanation of the circulation of heated water. Chapter II., Boilers (all kinds) and incrusted deposit from hard water; also the effects of soft water. Chapter III., Cylinders, tanks, pipes and fittings. Chapter IV., The tank system of apparatus. Chapter V., The Cylinder System of Apparatus (including the Cylinder-Tank System). Chapter VI., Special features and requirements. Chapter VII., Faults and causes of failure. Chapter VIII., Explosions and their causes; use of safety valves. Chapter IX., Low pressure boilers.

Mr. F. Dye is a recognised authority on this and allied subjects, and his book gives complete information on the principles of hot water supply, in a very concise form.

WARMING BUILDINGS BY HOT WATER.—By F. Dye. Published by E. and F. N. Spon. 1917. Price 8/6.

Chapter I., The Actions of Heat, etc. Chapter II., The Circulation of heated water in pipes. Chapter III., The Advantages of Warming Buildings by Hot Water. Chapter IV., The details of a hot water heating apparatus fully explained. Chapter V., Examples of a Low Pressure Apparatus; The Two Pipe System. Chapter VI., Examples of a Low Pressure Apparatus; The One Pipe System. Chapter VII.,

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Further examples of Low Pressure Apparatus; the Overhead Systems; Heating Factories; Heating Churches. Chapter VIII., Sizes of Circulating Pipes, mains and branches for two-pipe, one-pipe and overhead gravity systems. Chapter IX., Examples of low Pressure Apparatus for Glass-houses and Horticultural Buildings. Chapter X., Accelerated Circulations. Chapter XI., Miscellaneous details and difficulties.; Air in pipes; Loss of heat; conditions which interfere with the circulation; dipped pipes; causes of failure; chimneys; decorating radiators; covering pipes, etc. Chapter XII., Heat emission from radiators and pipes. Chapter XIII., Quantities. Chapter XIV., Drying-Rooms. Chapter XV., Testing heating plants when the outdoor temperature is above 32° Fahr. Chapter XVI., Boilers. Chapter XVII., Radiators; Cast Pipes and Fittings; Valves and Accessories; Pipe Joints, etc. Chapter XVIII., The High Pressure System. Chapter XIX., Warming Buildings by heated air.

Information on all hot water heating systems is here given in a concise form. Though a small book, it is very complete and there are many useful tables in the text and appendix.

A PRACTICAL TREATISE UPON STEAM HEATING.—By F. Dye. Published by E. and F. N. Spon. 1901. Price 10/-.

Chapter I., The Principles of Steam Heating. Chapter II., The Distribution of Heat. Chapter III., Steam Heat. Chapter IV., Designs of Low Pressure Gravity Steam Heating Apparatus. Chapter V., Designs of Apparatus which do not return the condensed water direct into the boiler, including exhaust steam works. Chapter VI., Quantities. Chapter VII., Boilers. Chapter VIII., Radiators, Valves, Fittings, Tubes and Appliances. Chapter IX., Heating Water by Steam. Chapter X., High-pressure heating. Chapter XI., Sundry information and data relating to Steam Heating. Chapter XII., Cooking by Steam.

This is a complete handbook of information on the subject and deals with heating by Low and High Pressure and exhaust steam, and also heating water and cooking by steam. There are many useful Tables.

6. GENERAL ENGINEERING.

STRUCTURAL ENGINEERING.—By J. Husband, Assoc. M. and Watts' Medalist Inst. C.E., etc., etc., Head of the Civil Engineering Department of the University of Sheffield, and W. Harby, sometime Assistant in the Civil Engineering Dept. of the University of Sheffield. Published by Longmans Green and Co. 8/6.

This is an excellent little book. Without being too bulky or detailed, it contains in readily accessible form a great deal of valuable information. The methods of design are modern and are treated in a very thorough and practical way, and are easy to follow.

Chapter I. deals with Materials. Chapter II. with Loads and Working Stresses, and includes Tables of Traffic Loads on Highway Bridges, and equivalent Distributed Loads on Railway Bridges for varying spans; Table of Stones' "Range" Formulae, etc. Chapter III., Bending Moments and Shearing Force. Chapter IV., Beams. Chapter V., Columns and Struts. Chapter VI. gives the design in detail of a Plate Girder. Chapter VII., Lattice Girders. Chapter VIII., Deflection, including the deflection and horizontal deflection of braced girders by the method of "Work." Chapter IX., Roofs. Chapter X., Miscellaneous and Tall Buildings. Chapter XI., Masonry and Masonry Structures, Foundations, Gravity Dams, Arches (rigid and hinged), and Tall Chimneys.

(*To be continued*).

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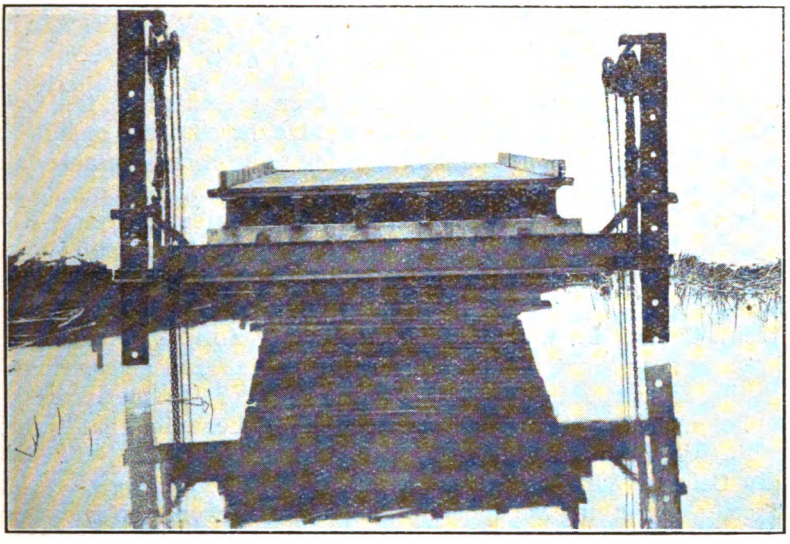
PROFESSIONAL NOTES.

BRIDGING.

As the pontoon equipment is now being re-designed to carry light, medium, and heavy loads, it is necessary to consider the question of a service trestle for use with this new equipment. The Weldon trestle has never been very popular and does not lend itself very well for use with medium and heavy loads. A new service trestle has therefore been designed and tested and is shown in the photograph.



The legs consist of 8-inch by 4-inch rolled steel joists and the transom is a 12-inch by 5-inch joist. The general dimensions of the trestle are the same as the Weldon trestle, but it will carry medium loads. The construction of the trestle is very simple. The transom has brackets permanently secured at each end; these brackets carry rollers through which the legs can slide. In this way the legs cannot splay or move out of line but each leg can slide up or down independently so as to suit an uneven bottom (footing) if necessary. The legs are drilled every six inches, and after the transom has been adjusted for height, it is supported on pins passing through these holes. Two types of shoe are provided. The normal shoe is of timber and measures 10 inches by 18 inches; this shoe is suitable for rocky bottom or ground which will support a pressure of four tons

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per square inch. A second shoe is provided which measures 2ft. by 3ft.; this shoe can be bolted on to the normal shoe and provides a pressure of just under 1 ton per square foot. The trestle weighs 1,180lbs. or 40 per cent. more than the Weldon trestle, but will carry an 8-ton axle load. Two trestles built up side by side as a tower, will carry heavy loads. The trestle can be put together and launched more rapidly than the Weldon trestle, and the legs cannot jamb against the transom under any conditions. The transom is raised or lowered by means of two 2-ton Morris's blocks. These blocks are a considerable improvement on the differential blocks for trestle work. The trestle has been tested with a 12-ton axle load. Further trials are to be carried out with this trestle.

THE TRANSACTIONS FOR 1920 OF THE ENGINEERING ASSOCIATION OF CEYLON.

THIS publication, a copy of which has been presented to the Corps Library by Major J. T. Rea, S.R.E.S., contains three articles on military engineering during the war which cannot fail to be of considerable value to the Corps. The first, by Major H. B. Lees, M.C., A.M.I.C.E., F.S.I., late Army Bridging Officer, Second Army, describes Military Road Bridging in France and Belgium, and includes some brief details of the launching of the various types of heavy bridges which are not contained in the reports already published in the R.E. Journal. The second article by Lieut.-Colonel F. J. Salmon, M.C., A.C.G.I., A.I.M.M., F.R.G.S., late R.E., on Survey Work on the Western Front, is a full and extremely interesting account of this important service. Colonel Salmon writes :— Never before this war have I realised the truth of the saying that "where there's a will there's a way." In the 3rd Battalion the "will" was usually Colonel Winterbotham's or, later, Colonel Keeling's. . . . Practically everything we took up was made to work. Never again will I listen to a counsel of despair! The third article gives some Notes on Mining at Cape Helles by H. L. G. Young, A.M.I.C.E., 2nd Lieut., 1/7th Scottish Rifles, attached to the 8th Army Mining Corps, and describes some interesting experiences of those operations.

F.E.G.S.

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NOTICES OF MAGAZINES.

MILITÄR-WOCHENBLATT.

No. 12.—*Battle of the Marne* (1914).—Major-General Baumgarten-Crusius contributes an interesting article on the influence of Lieut.-Colonel Hentsch on the orders to retreat in the battle of the Marne (1914). He quotes Von Tappen, who was D.M.O. at G.H.Q., to the effect that Hentsch was not endowed with full powers to order or approve of a retreat; that G.H.Q. gave no orders for retreat, and that Hentsch, on arrival at 1st Army H.Q. found the order for it had already gone out. He next quotes Von Kuhl (Chief of Gen. Staff 1st Army), who declares that the retreat had not been ordered when Hentsch arrived; that the situation of the 1st Army was quite satisfactory and that the Army H.Q. protested vigorously before it ordered the retreat which the self declared G.H.Q. plenipotentiary imposed upon it. We have, therefore, here two directly conflicting statements, and the writer proceeds to justify Hentsch, who can unfortunately no longer defend himself, by extracts from the report he made in May 1917, before his death. From this report, which will shortly be published in full, it appears that Hentsch did consider himself endowed with full powers and did order the 1st Army to retreat. He seems to have considered his action was universally approved at G.H.Q., until French accounts of the battle appeared; not till then was his decision ever questioned. He claimed an enquiry, which was agreed to, and in May, 1917, the following report was issued over Ludendorff's signature :—

" Colonel Hentsch received verbal instructions on the 8th September, 1914, from the C.G.S. to go to the 5th, 4th, 3rd, 2nd and 1st Armies, and clear up the situation. In case he found backward movements already started on the right wing, he was so to direct these that the gap between the 1st and 2nd Army should be closed, and the 1st Army directed as far as possible on Soissons. He was, within these limits, empowered to speak for G.H.Q. On arrival at 2nd Army H.Q. he found that this army had already independently decided to retreat to behind the Marne. He concurred with this decision and went on to 1st Army H.Q. There he invoked his authority to speak for G.H.Q. and gave orders for the 1st Army to retreat. He was justified in doing so because the situation was actually that mentioned in his instructions, viz., 'backward movements on the right wing already started.' "

Ludendorff wisely leaves to history the decision as to whether retreat was really necessary. Baumgarten-Crusius, however, has no such modesty. He claims that his book " The Marne, 1914," is history, and declares: (1).—Von Bülow was responsible for the

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retreat of the 2nd and right wing of the 3rd Army, which was unnecessary. (2).—The 1st Army H.Q. alone can be held responsible for its own retreat. (3).—Von Moltke was responsible for the whole of the western group of German armies being involved in the retreat.

From Kiel to Kapp, by Noske, ex-Minister of Defence, is a history of the revolution. Noske puts it down largely to the bad press his Reichswehr always had.

No. 13. *The Truth About the Marne*, 1914.—Nearly every number of the *M.W.B.* now contains at least one article on the Battle of the Marne, and, as Lieut.-Colonel Loebnitz now says, it is becoming more and more widely understood that it was the turning point of the war. The writer does not agree with the conclusion of Baumgarten-Crusius (in No. 12 *M.W.B.*) that Von Kluck was responsible for the retreat of the 1st Army. The whole question of Hentsch's intervention is very controversial and will no doubt be thoroughly explored for many years to come. The only point on which agreement seems to be fairly general is that G.H.Q. was much too far away and communications between it and the H.Q.'s of Armies too uncertain for it to exercise any useful control.

English Anxieties in Mesopotamia.—A not unfair description of the situation, as it was 3 months ago. The reasons given to explain our remaining in the country are (1) loss of prestige if we renounce our mandate; (2) strategic reasons which compel us to hold at least the Bagdad Vilayet, since withdrawal from there would leave Persia at the mercy of the Bolshevists and the road, in consequence, open to India, and (3) economic reasons which compel us to hold Mosul, as being the richest oil district.

Miscellaneous Notices.—The republican union intended to institute a public assembly in Munich, to which the Reichswehr soldiers were to be specially invited. This has been forbidden on grounds of public safety, in that this union works towards the arousing of political feeling in the army, and, consequently towards the estrangement of officers and men.

No. 14. *Militarism in France.*—The writer declares that France is doing all she can to increase the peace and the war strength of her army and the government knows that it can count on the nation for almost any sacrifices to this end. There are, however, many difficulties; first of all the economic situation which demands the utmost limitation of expenses, and though France has never allowed lack of money to stop her strengthening her army, this factor is bound to have considerable effect. Next there is the lack of population; in 1919 births were 200,000 fewer than deaths, and, though this rate of decrease is not likely to continue, the best she can hope for is a stationary population. The third great difficulty lies in the low physique of the recruits and it is in this direction that the greatest efforts are being made, every French boy from the age of 6 to the date of conscription being steadily strengthened in mind and body for service. The writer evidently admires the thoroughness with which this task is being undertaken and wishes Germany were able to do the same.

Officers' Pensions.—The rules regarding these are naturally very

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intricate, but the following examples show the sort of scale followed; a lieutenant, with 17 years' service and two children receives in all 7667 marks or about £31 per annum at present exchange. A major with 21 years' service and 3 children gets 15,028 marks.

No. 15. *German Operations during the Campaign in Italy.*—A review of this book, by General Krauss, of the Austrian army, explains how in the autumn of 1917, it was very difficult to spare any German troops for what was practically a "side show" in Italy. That it was a "side show" was due not only to strategic reasons, but to the fact that the Austrian troops had not sufficient fighting power. If they had all been like the Tyroleans or those hardy and stout-hearted Bosnians, it would have been a different story and the war would have passed into Southern France by Lyons. There seems to have been the usual controversy as to whether the attack should follow the valleys or the mountains. The Austrians were for the valleys. Surprise is expressed that the Italians did not try to hold the line of the Tagliamento, and the river itself is stated to have shown more sense, since it came down in such heavy flood as to defy all attempts at improvised bridging and taught both Germans and Austrians that at least some pontoons must accompany the division in river country. So strong was the stream that a wagon weighted with howitzer shell and pushed into the water to form a pier for a footbridge was lifted up and tipped over. The reviewer acquits General Krauss of anti-German feeling, but has a poor opinion of his skill as a leader or his accuracy as a historian.

The Fight for Tsing-tau.—Admiral Vollerthun wrote his account of the siege during his 5 years captivity in Japan, which 5 years, he says, showed him that the boasted chivalry of the Japanese is nothing but a bluff. He states that the money spent on fortifying Tsing-tau was well laid out and resulted in 3,700 Germans with 104 guns, of which 37 were of calibre less than 37 millimetre, being able to hold out against 63,000 assailants with 160 siege guns, besides the fleet, for a period of several weeks.

No. 16. *The New Austrian Army* will consist of 30,000 men organized in 6 mixed brigades. The cost will be enormous, no less than from 1,500 to 2,000 million kroner, as against 540 million for the whole pre-war army. The cost per head of the population will be from 24 to 32 times as much as in 1914.

The Profession of the Soldier.—This is an article written to attract the shy recruit. The thought of a real old time Pomeranian sergeant trying to persuade an out-of-work spartakist to be good enough to join the army is a not unpleasant one. However, once he joins he is in for 12 years and there is no discharge except for very special reasons, so no doubt the N.C.O. gets level in the end.

L. CHENEVIX-TRENCH, *Major, R.E.*

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REVUE MILITAIRE GÉNÉRALE.

June, 1920.

The Work of the High Command prior to Operations. (An extract from "Les Leçons Militaires de la Guerre), by Major Bouvard.—Napoleon says that the value of an army depends upon its mass and its rapidity of movement. The former is obtained by ensuring that reserves are available on the field of battle of the moment, and that the whole force is adequately provided with food and materials of all kinds, and means of replacing them when expended. The need for rapidity of movement intensifies the value of mechanical transport, railways and motors. But rapid concentration of the mass is not all. The front must first of all be equipped for defence, where suitable, and offence, partial or general, in those sectors which can be turned to account for that purpose. The fighting troops are too few for such work except in the actual front line, even if it did not interfere with their fighting powers and the necessity for constant training. A regular army of workmen must be provided to prepare the position in depth, including fighting and communication trenches, roads, light railways, observation posts, signals, artillery positions, ammunition depôts, command posts, shelters and camps, besides the extension of railways, extra platforms and stations, supply depôts, hospitals, etc. The problem as studied above refers particularly to the war of positions, but the difference in the case of a moving front is only one of degree.

Cavalry and Tanks, by Squadron Commander Bloch.—The writer considers that if cavalry keeps touch with recent scientific discoveries, it should play just as important a part in future wars, as it has in the past. The tasks it has to perform cannot be undertaken by mechanical devices, nor by infantry in motor vehicles. During the late war, where the two sides were extended from a foreign frontier to the sea there was no scope for cavalry, but with a moving front, in spite of its probable extent, reconnaissances of the enemy's flanks will be demanded, as also will a cavalry screen. During an action, it may be necessary to throw out quickly a cavalry curtain to cover disorganized troops, or the victor may wish for information in regard to any armies in reserve or reconstituted in the enemy's rear. Flanks may require rapid extension, for opportunities may occur of reaching the enemy's communications. Cavalry would also be required to widen an extensive breach in the enemy's lines, and to harrass his retreat. In defence they could close a breach in their own lines, or assist in a rearguard action. For such purposes cavalry could only be replaced by air-craft, swift tanks, or infantry in motor vehicles. The first is certainly necessary for the strategic reconnaissance, but cannot undertake a close and detailed reconnaissance, cannot see in misty weather, nor define absolutely the enemy's front, nor provide a screen for the main army. In pursuit aircraft can bomb a flying enemy, but cannot capture material and prisoners, nor obtain information which may enable some vital point to be struck at. If tanks, *with cavalry*, are useful in pursuit, they cannot replace the latter entirely, cannot reap the fruits of victory,

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prisoners, material, and information, their view is restricted, intercommunication over an extended front is impossible, and they would be at the mercy of a single small gun. Infantry in lorries are tied to the roads, and are vulnerable while there, cannot reconnoitre, nor seize opportunities as can cavalry. However, useful as a reinforcement, they cannot replace the cavalry in a pursuit. In defence they cannot rapidly throw out a covering curtain in front of disorganized troops, their mission should be to form a solid barrier in rear of the cavalry curtain. Cyclists cannot move rapidly across country, and if called upon to act as cavalry as well as infantry would soon be exhausted. The co-operation of all these will increase the value of cavalry, but the necessity for the latter as well remains absolute. The principal hindrances to cavalry in the modern battle are (1) want of space for manœuvre and the long range of modern weapons. (2) Material obstacles and zones of heavy bombardment. (3) The efficiency and rapidity of fire (a) of artillery, and (b) of machine guns. A reference to the duties assigned to cavalry will show that in a war of movement the first three disappear more or less. To dispose of the last, cavalry can use dismounted fire and its own guns and machine guns, but the former are confined to the roads. If they had a tank, which would not impede their movements, capable of fighting with them whether mounted or dismounted, the enemy machine guns would be useless. Again in the defence the tank would be of great assistance in strengthening the cavalry curtain. The cavalry tank must move on its own wheels ready for instant action, and should be capable of travelling at 12 kilometres per hour at least, or more, if obtainable. It should be able to cross gaps two metres wide, and be proof against rifle fire. The dimensions should be as small as possible so long as the two metre gaps can be crossed, and the eye of the commander is 1 m. 60 above ground. Crew, a commander and driver. Weight 3½ tons, if practicable, to enable it to use light bridges, but the other considerations mentioned will probably entail a weight of at least 10 tons. Petrol capacity 10 hours. Each division (three brigades) of cavalry should have a battalion of three companies of tanks, and a light repair and supply section, each company comprising four sections and one echelon, and each section three tanks, one armed with a gun, and two with machine guns. The company echelon consists of four waggons for supply and repairs, and two or three lorries, which should have the same means of propulsion as the tanks, to enable them to follow over the same ground. Cavalry tanks must be spared as much as possible and not sent on small reconnaissances, or with parties of less strength than a squadron. With dismounted cavalry the tank tactics would follow those prescribed for the infantry tank. The section would be under the command of the cavalry unit which it supports. The tank company would be at the disposition of the cavalry brigade commander, and the battalion under the orders of the cavalry division commander. When approaching the enemy the tanks would be in rear of the manœuvring cavalry; when the latter forms for action the tanks would pass them and destroy obstacles to their progress, and the objective obtained would concentrate to intervene in the counter-attack. A cavalry guard must accompany

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each section of tanks to cover it by mounted fire, or drive away a solitary anti-tank gun which may suddenly come into action, to maintain communication between the sections and the cavalry main body, and to act as ground scouts. The tanks with cavalry, unlike those with infantry, have not to conquer or occupy ground, but only enable it to be passed over. Cavalry and tanks are made to work together. They can cross the same ground, and the conditions suitable for a cavalry action are equally favourable to tanks. Tanks are invaluable for destroying machine guns which may tend to hold up the cavalry.

July, 1920.

Military Legislation, by Capt. H. Mirauchaux.—A plea for the enhancement of the status of the division in the coming legislation for the future of the French army. The writer points out that the division as constituted at the commencement of the war was limited in its activities by being dependent on its army corps for so many of its essential units. When during trench warfare, it was found necessary to relieve divisions in the fighting line by fresh divisions from the rear this organization was found to be unworkable, for the division at the rear was not able to live on its own unaided resources. Gradually units were added to it, such as motor transport for the hospital, infantry and artillery ammunition columns, an extra company of engineers, and supply column, and at the time of the armistice the addition of a second squadron of cavalry with one or two M.G. sections was under consideration. In view of the fact that the division does all the work, whilst the corps only co-ordinates and commands, it is only right that the divisional commander should be provided with the necessary resources for efficiently carrying out his duties. The division should be self-contained, and a sort of small army corps. This would lead to a livelier esprit de corps, and to a better understanding between every branch of the service, including signals, aviation, and tanks, and therefore greater efficiency.

A. R. REYNOLDS.

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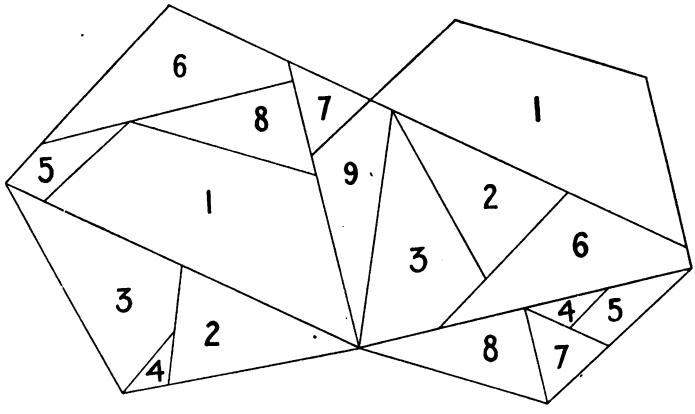
DISSECTION PUZZLE.

THE accompanying dissection of a pentagon into 9 pieces which will form a hexagon may be found interesting. The actual puzzle is, I think new, but the clue will be found in Mr. H. E. Dudeney's "Amusements, etc." Can the transformation be made in fewer pieces? I do not think so.

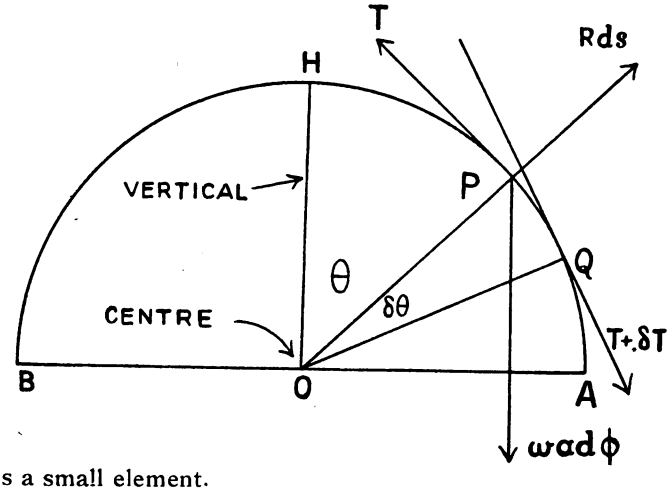
L. A. ARKWRIGHT, *Lt.-Col.*



PROBLEMS.

PROBLEM 18 (Solution).

An elastic string of weight (W) per unit of length when unstretched and of modulus of elasticity $2aW$ rests in contact at every point of a smooth vertical semicircle of radius (a) whose base AB is horizontal and whose arc is uppermost. The ends of the string reaching down to A and B. Find the unstretched length of the string.



PQ is a small element.

Suppose that PQ if unstretched would subtend $\delta\phi$ at centre.

Weight of PQ is $a\delta\phi w$ and may be supposed to act at P.

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Resolution along tangent at P gives

$$T = wad\phi \sin\theta + (T + \delta T)\cos\delta\phi,$$

whence
$$\frac{dT}{d\phi} = -aw\sin\theta \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1).$$

Which is right as regards sign as T decreases as θ increases.

Hooke's law gives

$$\frac{a\delta\theta - a\delta\phi}{a\delta\phi} \times 2aw = T.$$

Whence
$$\frac{d\theta}{d\phi} = 1 + \frac{T}{2aw} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2).$$

Combination of 1 and 2 gives

$$\frac{dT}{d\theta}(T + 2aw) = -2a^2w^2\sin\theta,$$

whence
$$T^2 + 4awT = 4a^2w^2\cos\theta,$$

whence
$$T = 2aw\left(\sqrt{2}\cos\frac{\theta}{2} - 1\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3).$$

No constant is added on integration as T = 0 when $\theta = \frac{\pi}{2}$.

Combination of 2 and 3 gives

$$\frac{d\theta}{d\phi} = \sqrt{2}\cos\frac{\theta}{2}.$$

$$\therefore \quad \sec\frac{\theta}{2}d\theta = \sqrt{2}d\phi.$$

$$\therefore \quad 2\log\tan\frac{\pi+\theta}{4} = \sqrt{2}\,\phi$$

as both sides vanish when $\theta = 0$.

When $\theta = \frac{\pi}{2}$ $\phi = \sqrt{2}\log\tan\frac{3\pi}{8}$.

Hence unstretched length is

$$2a\sqrt{2}\log\tan\frac{3\pi}{8}.$$

Problem 21.

Show that if $ax_r^2 + by_r^2 + cz_r^2 = 0$ where $r = 1\ 2$ or 3.

This is only a concise way of saying if

$$ax_1^2 + by_1^2 + cz_1^2 = ax_2^2 + by_2^2 + cz_2^2 = ax_3^2 + by_3^2 + cz_3^2 = 0.$$

Problem 22.

Sum the series

$$\sin 2x - \tfrac{1}{2}\sin 4x + \tfrac{1}{3}\sin 6x \text{ to infinity.}$$

J. M. Wade, *Lt.-Col.*

Solutions.

Correct solutions have been received of No. 16 from Major G. E. Painter and No. 17 from Major C. R. Satterthwaite, O.B.E.

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THE BELGIAN DEFENCES IN 1914.

By COLONEL LORD SYDENHAM OF COMBE,
G.C.S.I., F.R.S.

IN 1890 the late King of the Belgians asked H.M. Government to send an officer to examine and report upon the defences then in course of construction. I was selected to undertake this work, and the article by General X in the *Revue Militaire Générale*, which has been summarized by Brigadier-General J. E. Edmonds, is therefore of special interest to me after the lapse of more than thirty years.

My report was necessarily treated as secret, and I do not know whether it led to any useful result; but most of my views have been confirmed by the events of 1914. The construction of the defences of Liége and Namur as well as that of the outer ring of forts round Antwerp had been the subject of much controversy in Belgium, where General Brialmont's projects were sharply criticized. Lieut.-General Chazal, a late War Minister, insisted that the entrenched camps of Liége and Namur would require garrisons of 25,000 to 30,000 men and would, if weakly occupied, be liable to capture by a *coup de main*. It was also maintained that the measures proposed would involve a permanent increase of 50,000 men to the Army. On the other hand, General Pontus, the then War Minister, reported that:

Le dispositif proposé n'exige pas aucune augmentation de nos forces. L'effectif de notre armée ne devra être augmenté á raison de leur exécution, mais des changements devront être apportés dans la constitution et la répartition de l'artillerie.

The Clerical Party was strongly opposed to any increase of the army, and this assurance, which appeared to me to be radically unsound, may have enabled the measures to be carried in the House of Representatives by 81 to 41 votes, and the defences of the Meuse were commenced in July, 1888. A further discussion had taken place as to the objects of and the nomenclature appropriate to the new defences. The term "entrenched camps" was expressly repudiated by the Government which officially announced that:

Les têtes du pont dont il s'agit ne peuvent être confondues avec des camps retrenchés. Ce sont de simples pivots de manœuvre, des places d'arrêt.

As I pointed out, a *pivot de manœuvre* implied the existence of an effective field army able to take advantage of fortified *têtes du pont* for operations on either bank of the Meuse. In the absence of an

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adequate field army, the defences of Liége and Namur could only play the role of *places d'arrêt*, and I stated that:

"It is not the protection of Belgium against invasion which is directly sought, but the closing of a route connecting the territory of two other Powers, who, it is assumed, must sooner or later be again at war, and either of which might select this route as offering advantages in striking at the other . . . If, however, Belgium possessed an effective field army, capable of being rapidly mobilized, the strategic value of the positions of Liége and Namur would assume far greater proportions."

For perimeters of 31 miles (12 forts) and 24½ miles (9 forts) of Liége and Namur respectively, I estimated total garrisons and field forces of 43,000 and 34,600; or, omitting provision for outpost systems on the inner third of the defensive lines, a grand total of 53,000 men. At this time the Belgians could only have mobilized about 80,000 men; but General Brialmont had stated his belief that Great Britain could "without much difficulty" place 65,000 to 70,000 men "in a central position in rear of the Meuse" by the end of the 10th or 11th day after a declaration of war—an achievement then impossible. I was always convinced that a violation of Belgian territory was more probable from the French than from the German side, and I maintained that, "Unless the British guarantee is admitted to be a dead letter, it would seem to be the obvious policy of this country to press upon Belgium the reorganization and increase of her army." Most fortunately the military position of Belgium had been greatly improved before 1914, and the inestimable service which her gallant troops rendered to the Allies can never be forgotten. Liége and Namur played their part as *places d'arrêt* by securing delay which was vitally important to the French Army and our Expeditionary Force.

General X claims a resistance of 13 days for Liége, which the Germans, apparently underrating its resisting power, expected to capture by *coup de main*; but they were able to pass between two of the forts, where I reported the interval to be blind and dangerous, so that the town was in their hands before all the eastern forts had fallen. Namur is credited with a longer resistance; but no attempt to carry it by storm appears to have been made, and a bombardment of only two days proved decisive. From the point of view of permanent fortification, the interesting question is whether these very expensively fortified positions justified their existence. I do not know what forces were available for each; but I consider that the heroic General Leman did all that was possible, in the circumstances, to hold Liége. The Germans had planned their invasion to the last detail and crossed the frontier before a state of war existed. There was no time for the large amount of work required to put Liége in a proper state of defence, even if adequate forces were available on

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the spot. My estimate in 1890 was that " the Germans could place 20,000 men in front of Liége in 5 days from the date of mobilization, to be followed rapidly by a much larger force." They had, however, partially mobilized in advance; their railway system had been developed, and they were able to improve on this estimate.

All the works were of the same type, a huge central mass of concrete surrounded by deep and well-flanked ditches. The armament consisted of 15 and 12 cm. guns, 21 cm. howitzers and 55 mm. Q.F., all in armoured cupolas of a form determined by the long experiments at Bukarest in the winter of 1885-86 which were reported on in detail by Major (now Major-General Sir D.) O'Callaghan and myself. The forts were therefore artillery positions pure and simple, the 55 mm. Q.F. guns (disappearing) being substituted for infantry. The 15 and 12 cm. guns were all ordered from Krupps and there were, I believe, long delays in delivery, while the guns themselves, of weak type, were stated to be unsatisfactory. The direction of fire in each fort depended mainly in an armoured disappearing observing station raised into position by hydraulic power.

This general conception of the fortification position appeared to me unsuited to the circumstances.

" The forts are practically isolated positions in which a certain armament is concentrated upon a very small area . . . If the fire of the forts is to be mainly relied upon for the defence of the position, large intervals are permissible only where the ground is open and fairly even. In many parts of the Meuse positions the ground is sharply accentuated and rendered very blind on account of the large amount of standing timber. Generally speaking, the forts cannot be regarded as providing adequate defence of the intervals. All the railways and the principal roads are commanded at effective ranges; but the portions seen from the works are comparatively short . . . There are, however, a number of excellent roads which cannot be said to be defended at all by the fire of the forts, while on account of the great accentuation of the country, masses of men could in many cases be brought close to the fort line. In these circumstances, the defence of the intervals by a field force, able to establish and maintain an effective outpost system, assumes the greatest importance. The indirect fire of the forts themselves—the greater part of their fire at moderate ranges—would depend on observations carried on from positions outside."

My general conclusion was, therefore, that:

" The effective defence of the entrenched positions of Liége and Namur will depend mainly on a field force guarding the intervals."

" These positions to be of any real value must be fully prepared for defence within a very short time of a declaration of war."

How far the organization of the defence, the preparation of

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intermediate infantry and artillery positions and the clearing of the ground had proceeded when the storm suddenly burst, I do not know, and any accounts which may be published of the attack on Liége and Namur will be instructive.

It was my view, in 1890, that the conception of the permanent defences of the Meuse was wrong. The crowding of artillery into small conspicuous areas was, I believed, a mistake. If the guns and the observing stations of the forts could be placed *hors de combat*, these expensive works could render no further assistance to the defence, which would then depend entirely upon that of the intervals. By 1914, the German provision of mobile heavy howitzers and of aeroplanes able to direct their fire had still further discounted the designs of M. Mougin and General Brialmont. On the other hand, in so far as the existence of the forts necessitated the bringing up of heavy ordnance—such as the 42 cm. howitzers—delay, which was invaluable to the Allies at this juncture, was entailed upon the Germans.

Antwerp was defended in 1890 by a ring of 12 very large forts, about 3,600 yards from the enceinte. Their design is well known and was open to much criticism. Those which I inspected were already long obsolete and were armed with old type guns "most of them cast iron." It had been decided to make an outer ring of 17 forts at a minimum distance of about 15,000 yards from the enceinte. Of these works, 6 were nearly completed, and those I saw were open to great objection. The total length of line to be defended was about 41½ miles on the right bank of the Scheldt; but reliance was placed on inundations protecting the northern sector. Six days were stated to be needed for completing this inundation; but "a good obstacle could be obtained in two days." In other sectors "a great clearance of timber, requiring a perfected organization and many days of labour," was needed to enable the forts "to defend their own immediate front and intervals." Antwerp had a respite and may have been better prepared for defence than the positions on the Meuse. From the nature of its permanent works, however, it was equally doomed directly the Germans could bring up siege artillery, unless it held a field army. Whether this was realized, as it should have been, when the decision was made to throw in a British force, largely ill-trained, I cannot tell. Several important steps were taken during the war which seemed to show ignorance of information that must have been available. Yet Antwerp, like Liége and Namur, served to gain time and to detain large German forces which, otherwise employed, might have been dangerous to the Allies.

General X laments the neglect of fortification which, he considered, prevailed in France before 1914, and it is obviously futile to build costly permanent works unless they are kept up to date, adequately

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armed and prepared for defence. Verdun as a fortress hardly existed ; but for many weeks the fate of France seemed to hang on the defence of this region, and nowhere did the French army acquit itself more gloriously. The permanent fortification on the Eastern frontier served its purpose in determining the line of the German invasion, and the perfection of the preparations for mobilizing the army was of infinitely greater importance than any technical additions which could have been made on the line of the Vosges. What might have happened if the Germans had respected Belgian neutrality and thrown their weight, with a powerful siege train, on the Eastern side will remain an interesting speculation.

The problem of the future of fortification awaits solution. The large expenditure on permanent passive defence, which has found favour at some periods in the past, and the formal types, which existed in 1914, are not likely to be repeated. The war has shown that, except in a limited sense, fortification cannot be substituted for men. " Invisibility,"* for which I pleaded in 1886, was found to be an essential form of protection, and has added a horrible new word to the language. The development of artillery and the even greater development of the means of directing fire have rendered the accustomed form of fort a helpless shell trap. At the same time, the tank has reduced the field fortification of the text books on which we were brought up to impotence. European wars in the future may be decided in the air. The conditions of the British Empire are, however, so varied that our pre-war ideas of fortification have not become universally obsolete. I earnestly trust that the officers of the Corps, of whom so many have gained invaluable war experience, will devote themselves to the solution of the new problems on which our security may depend.

* *R.E. Professional Papers*, Vol. XI., page 195.

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TOPOGRAPHICAL AIR SURVEY.

By LT. COL. G. A. BEAZELEY, D.S.O., R.E.

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Introductory.—The survey methods described in these notes are independent of air photography. Their inception arose, and need for them was felt, in Mesopotamia, where it was found impossible satisfactorily to piece together a very large number of air photos taken in strips over enemy country far in advance of our lines, beyond the reach of triangulation, and where, as no reliable maps existed, no fixed points were available to which to tie down these scattered strips. Gaps also occurred between the strips, owing to the occasional failure of the camera shutters, and these added to the difficulty of piecing together the patchwork.

It was originally suggested to the G.H.Q. by the writer of these notes that there was no reason why a means of surveying or sketching typographically from the air should not be possible if a trained surveyor were available, and he received instructions from G.H.Q. to experiment and see what could be done in this line. A lull in the operations permitted his being attached to one of the air squadrons, and in a fortnight sufficient experiments had been carried out, the requisite instruments made, and a workable system evolved.

There was neither time nor opportunity for teaching the system to any of the R.A.F. officers. It was one thing for a fully trained and experienced surveyor rapidly to master the methods, but quite another thing to send an officer who was not a trained surveyor to carry out surveys over the enemy lines. The consequence was that the writer was shortly afterwards called upon to carry out surveys himself over enemy territory well in advance of our lines.

Five successful trips were made and a considerable area was sketched and additional useful information collected. On the fifth trip a reliable form of sun compass was evolved, as the ordinary form of sun dial was found to be of no practical use.

Unfortunately for the successful completion of exhaustive experiments, during his sixth trip the writer was shot down near Kirkuk on 2nd May, 1918, and taken prisoner by the Turks. No further experiments could be made till July, 1919, when he was passed as fit enough to fly once more and the experiments described below were carried out at Andover in Hampshire.

Methods used and Experiments carried out.—Before any attempt could be made to carry out an "Air Survey" with any degree of accuracy it was necessary to find means of keeping the sketching

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board constantly oriented, *i.e.*, with its true north and south lines in the plane of the meridian, and approximately level. These are fundamental principles both in 'ground' and 'air' survey. It must be remembered that an aeroplane seldom keeps a constant course, but "yaws," like a sailing vessel when under the action of waves and wind, and that consequently the board can only be kept truly oriented by being constantly moved round on its pivot. Any change in direction made by the longitudinal axis of the aeroplane must be met by a corresponding change in the orientation of the sketching board. This orientation can be accomplished either by aid of a magnetic compass whose dial index after being corrected for deviation, etc., points to the true north or by means of sun azimuths plotted on the board, as will be described later.

Dealing first with magnetic compasses, in each machine used a pocket liquid card compass was tried. In a Handley Page it had at times an amplitude of about 10° on either side of the mean line, and thus gave only a very approximate idea of where the true north was. In an Aero and Bristol Fighter the compass could not be kept steady at all, in every case centrifugal action was set up in the liquid and rendered the compass unreliable. An aperiodic type of compass in common use in aeroplanes was tried in a Bristol Fighter, and gave fair results when flying along a perfectly straight line on the earth's surface, such as an old Roman Road, the maximum amplitude being about 3° on either side of the true position. But on a constantly changing course it proved quite useless owing to inertia and the amplitude set up in the liquid by centrifugal action. It never gave true direction instantly. The course according to the compass would be somewhat similar to that shown in *Fig.* 17, in which the points *a,a,a,* are a succession of positions taken along the course by re-section from the starting point and by ground speed scale compass set with index reading true north. The course according to the compass is denoted by the firm line, the actual course was probably as shown in *Fig.* 18.

To do away with one cause of centrifugal action in the liquid—the frequent orientation of the board, to which the compass had hitherto been attached—a special compass reflector was tried in Mesopotamia used in conjunction with a reliable compass fixed to the side of the fuselage, instead of to the sketching board, details of which will be given hereafter. This apparatus proved fairly successful, and further trials of it were to have been made at Andover, but could not be arranged before the experiments there were brought to a close.

A stabilized form of compass (non-magnetic) controlled by an instrument based on the principle of the gyroscope was being tested under the Air Ministry, and if successful this instrument will be very useful for air survey work. The compass must keep constantly

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pointing to true north, but the complete apparatus must not be too heavy for the aeroplane.

The use of the pilot s compass is eliminated by the fact that there is no time to plot bearings with a protractor even in a machine which can fly at so low a speed as 65 miles per hour. Further, to be of any use a compass must give true magnetic bearings to all points of the compass instantly, but this is prevented by inertia which keeps it from settling down at once to the true bearing. It is unsuitable for air survey work, it was tried in Mesopotamia and given up in favour of sun azimuths.

In the experiments dealt with in this report azimuths, at half hour intervals, for the mean latitude and declination of the sun, were used. These were plotted on the board, and a long needle was stuck into it vertically in the centre of the dial. The board was turned on its pivot till the shadow thrown by the needle coincided with the time shown by a mean-time watch, which had been corrected for difference in longitude from Greenwich and equation of time. It is always possible to keep the sketching board approximately level with the help of a small circular level, or ordinary level bubbles placed at right angles to each other.

To provide for the contingency of the sun being temporarily obscured a small liquid compass was fixed and let in flush with the sketching board, it was customary on the way out to the day's work to note the position of the magnetic north when the board was oriented by the sun compass, and to shift the pointer to coincide with it. Then if the sun became obscured the board could be oriented by help of the compass until the sun shone out again. This method is of course liable to some error, which is indeterminate, but for the short period involved no great error in the survey work will be introduced, so long as no attempt is made, for instance, to fix objects at a distance on either flank.

Four patterns of sketching boards were used, three of which were specially for area work:—(1) a small board, 9 inches square, with rounded corners and a recess for the compass, used in the front cockpit of a Handley Page, where there is no room for a bigger board ; (2) a similar board 13 inches square, used in an Aero and Bristol Fighter ; (3) a board similar to (2) with an aperiodic type of compass instead of the small pocket type. For route traverse work (4) a board somewhat similar to the familiar cavalry sketching board was used, designed to hold a slip of paper 60 inches long and seven inches wide, total size over all 13 inches square. On this board paper sun dials were mounted on either side, as the paper strip had to be wound off constantly as the work progressed. Additional sun dials can be plotted on the paper itself but if they are used great care must be taken to remove the dial pin each time the paper is wound off or on the rollers. A light wooden mallet was used to drive the pin

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firmly into the board. The following are also required :—protractor, hair-spring dividers, proportional compass and push pins.

A set of wooden speed scales on the scale to be used is required for the following speeds :—120, 115, 110, 105, 100, 95, 90, 85, 80, 75, 70, 65, 62½, 60, 57½, and 55 miles per hour, two scales to each piece of wood. These are 'ground' and not 'air' speed scales. They can be used as sight rules for re-section from back points, or for cutting in detail to a flank. The best scale for general use is ½ inch to 1 mile, as it is easier to draw on this scale than on the ¼ inch. Larger scales require bigger boards which cannot very well be used in the machines in use.

Thin lithographic paper mounted on cloth, as used for printed maps, is the best for working on, and can be obtained from the Ordnance Survey, Southampton. Unmounted paper gets torn by the air blast.

A supply of HHH, red, blue, and green chalk pencils, knife and rubber should be kept. When actually at work in the air two or three lead pencils should be taken as they are apt to be wrenched out of one's hand by the rush of air. No coloured pencils can be used till the day's work is over and the observer is returning home. There is no time to handle them while actually at work.

Machines used.—The B.E. 8 is the most suitable type of machine, its speed is moderate, fuselage stiff, vibration not excessive, it has a roomy compartment aft for the observer to work in, and a 15 or 16 inch board could easily be used. A turntable seat, which enables the observer to turn round and face forward when necessary, and to which the sketching board can be fixed, is found to be more restful than a fixed seat on a long flight. This machine can keep in the air for four hours and throttle down to 65 miles per hour comfortably. The engine is air-cooled. The wings interfere less with the view than in any other type of machine. The pilot is close to the observer. This machine was used with success in Mesopotamia by the writer of this report.

B.E. 2.E. was tried in Mesopotamia but found not suitable as the observer has to sit in the forward compartment which has a poor field of view.

Handley Page is unnecessarily large and requires too many hands, its fuselage is too wide and it is impossible to work satisfactorily from the after compartment. The forward cockpit is too small and breezy, and a 9″ by 9″ board is the largest that can be used there. Once past the mark no back re-section is possible in this machine, drift cannot be properly estimated or course satisfactorily plotted. There is no time to make calculations with a drift instrument.

The Aero cannot remain in the air long enough, at the maximum under two hours, which gives too narrow a margin of time, its speed is moderate, vibration excessive. It is in fact a cheap type of machine

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and not very satisfactory for air survey work, the wings interfere with the view when sitting facing backwards and the observer cannot see vertically below the machine.

The Bristol Fighter has distinct advantages in some ways, but it is rather too fast except for a fully trained hand and the engine does not work smoothly at speeds below 80 miles per hour. The observer's cockpit is rather small, the machine vibrates a good deal, which makes it very difficult to write legibly. The examples of air sketches accompanying this report were all done from a Bristol Fighter, except the Mesopotamian sketch which was done from a B.E. 8. A board larger than 13" by 13" could be used if special arrangements were made for it, the cockpit would require slight modification. It is a distinct disadvantage that the machine can keep the air for only two hours.

The best type of machine would be one built on the lines of a D.H. 9 or a B.E. 8, with an engine to drive it at a cruising speed of 65 miles per hour while the observer is at work, and at other times at a higher speed, say up to 90 miles per hour. The machine should be capable of carrying two observers, one behind the other, besides the pilot. Petrol supply should be sufficient to last out fully 4½ hours.

Method of work.—The experience gained by the writer indicates that it is best that the observer should explain to the pilot only generally what course he is to take, and should retain complete control as to the exact air routes to be followed. A pilot cannot in fairness be expected to maintain a course set on a map and look after a machine properly at the same time. It is therefore essential to the observer that he should have some simple means of communicating with the pilot.

As in other branches of survey work practice is required, the principal difference between air work and ground work being that in the former the observer has to work at a far more rapid rate and the work must be carried on without relaxing his attention for a moment. After a little practice, however, it is not difficult to keep the board fairly level and properly oriented, and with further practice this is done automatically.

Care must be taken frequently to re-sect the position by rays from back points drawn in quickly with the sight rule, and having got this ray to plot the position from the starting point by means of the speed scale, after noting the time by stop-watch. The speed scales are graduated in distances covered in minutes and fractions, the actual ground speed being known with reasonable accuracy. Detail should be drawn in as it passes underneath or to either flank, using the speed scale and stop-watch for distances. The angles which roads make with the line of flight should be noted. In country similar to that shown in the sketch of ground in Mesopotamia all these operations are not difficult with a little practice, the writer felt competent

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to do this class of work after eight days' practice, and it is over country of this nature that this form of air survey can prove most useful. Work over highly cultivated and organized country like England is more difficult and calls for a higher rate of skill and unremitting attention on the part of the surveyor.

Over civilized countries this method of survey by eye would prove invaluable for preparing an accurate skeleton on which to tie down air-photo mosaic, it would be possible to run traverses over a large stretch of country and adjust these to include quite a sufficient number of fixed points by which to tie down all the photos, within 5 % of their true positions on the ground, given a suitable machine and trained officers. This form of frame work would be invaluable over country that cannot be triangulated or traversed. With these tie lines the same officers could go over the ground and fill in rapidly detail which is not included in the air-photo mosaics. In country similar to that shown in the detail sketch of the Southampton area it is far better only to sketch in what one can, taking great care (*a*) to keep the board level and oriented and (*b*) to keep the course carefully plotted by re-section and speed scale; then, after inking up what details are known to be accurate, to go over the ground again and fill in blanks, which is easy as sufficient detail has already been inked up to enable the rest to be done to a great extent by eye. Never get flurried. The writer confesses to having had a feeling of nervousness at first when the detail to be cut in seemed more than he could cope with, but the more practice one gets the greater one's confidence and when confidence is gained it is all right.

Three months' training is recommended, though shorter periods may suffice with officers who have a special aptitude for the work. The great thing is to learn to gauge the scale of everything quickly.

Before starting work a short run should be made between two points in a line down or up wind whose distance apart is known. This should be explained clearly to the pilot, who should show before starting that he understands what he has to do. It is assumed that the observer has previously ascertained the ground speed of the machine in still air equivalent to the air speed which he intends to maintain. The Bristol Fighter used by the writer of this report was a very reliable machine and gave a value of 83 miles per hour ground speed at 2,500 feet for an air speed of 80 miles per hour in still air. It is however always advisable to test this periodically up and down wind on a measured course.

Having run along the measured course, say down wind, with a stop watch, the speed of the wind can easily be obtained by subtracting the deduced ground speed in still air from the same down wind. Corrections can then be applied to the latter for all other courses while at work.

If time permits it is far better to run both up and down wind on the

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measured course. A reliable ground speed can then be obtained from the formulæ :—

$$\frac{\text{Speed down wind} + \text{speed up wind}}{2} = \text{ground speed}$$

$$\frac{\text{Speed down wind} - \text{speed up wind}}{2} = \text{wind speed.}$$

The starting point of the day's work, the direction from which the observer wishes to approach it, the speed to be maintained and height at which the machine is to fly, having been explained to the pilot, it rests with the observer once he is past the starting point to control the course subsequently taken. The simplest way of doing this is to tap the pilot's left or right arm to indicate a slight turn to port or starboard, the taps being repeated until the machine is on the desired course. When work is completed the pilot should be handed a slip of paper to that effect. No other signals should be necessary unless the engine is giving trouble and it is necessary to return home, when the pilot can tell the observer his reason for doing so.

Telephones to fit the head were not used by the writer, as the pressure on the back of his head from the propellor blast was as much as he could stand without adding to the discomfort of having the telephone headpiece fixed on his head as well. But there is no reason why a telephone should not be used. It would render communication with the pilot far easier, and the difficulty about the air blast could easily be overcome in any machine fitted specially for survey work. In fact a screen to protect the head from the air blast is a *sine quâ non* for effective work on account of the occasional necessity of turning round to look at the approaching ground. A knowledge of what detail is in advance is sometimes essential and turning round to obtain this is a very unpleasant undertaking in a Bristol Fighter which has not been fitted to protect the observer from the air blast. Exact knowledge of the ground speed and of the direction and force of the wind, the power to re-sect one's position from fixed points in rear of the machine, and reliable means of orienting the sketching board, are all essential factors in successful air survey work. The methods of ascertaining the ground speed and the force of the wind have been dealt with already. The direction of the wind can be obtained from the ground, both before starting and also on landing after a trip, by noting the bearing along which the lowest clouds are being driven. In the air a drift instrument can be used at working height in clear weather. Re-section from fixed points in rear can be done by aligning the ground speed scale rule like a sight rule on the object. Local mean time is required for the sun compass.

The observer should fly at the height of 6,000 feet if possible. At

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that elevation he gets a far better command of the country and can work more quickly and include a far larger area per run than at, say, 2,000 feet. But though this is practicable in arid countries, in England it is very seldom that the air is sufficiently free from clouds. At low altitudes there is a tendency to exaggerate the scale of things.

In a highly civilized country like England an area sketch cannot be done in a single operation. Route traverses must be carried out along the sides and diagonals. A sketch of an area of 500 square miles would require at first about two trips of 1½ hours each in a Bristol Fighter. These must be corrected to scale and adjusted and then transferred and fitted together on a new board. During the flight it is necessary to work out approximately the ground speed on the various courses and use the ground speed scale which most nearly corresponds in each case. The ground speeds will vary, as the prevailing wind has a different effect upon the ground speed at each change of course. The estimated speed for each course should be noted down and can be worked out again and corrected after landing, and the traverse stretched out or contracted by proportional compass. A final adjustment is made when all the tie lines are being fitted together. Here two corrections will be found necessary:—(*a*) final correction for scale, and (*b*) final correction for azimuth and direction.

The next step is to run traverses along the central meridian and central east and west line, and afterwards the detail can be filled in gridiron fashion, the number of lines and their distance apart being governed by what the observer can adequately fill in on both sides of the gridiron lines. No attempt should be made to fill in the blanks straight away; the observer should first land, pencil in and colour up the work already done and then complete the sketch by flying over the blanks and doubtful parts. Any attempt to amplify or fill in over roughly pencilled work only leads to confusion.

The control of a gridiron course cannot be left to the pilot; the writer found it necessary to keep it in his own hands throughout the whole operation, including the filling in of blanks as suggested above.

An important route should never be flown over vertically as from that position nothing can be seen of it from the machine; the observer should keep at least half a mile to one flank. If the wind is blowing obliquely to the course this will require the constant attention of the observer.

For area work a perfect square or rectangle should be adopted, and the sides, diagonals, central meridian and east and west lines should be laid out accurately on a blank board. The machine should be kept exactly over these lines by constant re-section from back fixed points. At first no great amount of detail should be included. After the course has been plotted carefully and the traverse lines have been adjusted and inked up there is no difficulty in filling in the detail.

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Before commencing work sun azimuth dials should be protracted in all the four quarter squares, as the arm gets in the way of each dial in succession as the board is orientated on different courses, necessitating in each case the shifting of the dial pin.

A system of simple symbols is essential, such as :—

F. for farm buildings,	R. for road,
V.L. for valley,	W. for wood,
R.R. for river or stream,	STN. for railway station,
Rly. for railway,	and so on.

Practice at retaining in one's mind a pictorial representation of the ground is essential, as much may be jotted down on the sketch from memory after landing. The writer of this report invariably went over his work on landing and amplified his sketch in this fashion.

When learning to survey in the air the observer should compare his work with the published maps and note where he has gone wrong, for future guidance. This teaches him a lot and helps him to avoid similar mistakes in future. There is a tendency to exaggerate the scale, to draw in roads at the wrong angle and to omit important detail which is plainly visible from the air. Anything tending to affect the ground speed of the machine should be carefully noted at the time, or the scale of the sketch will vary in places from the true scale.

When altering course from one traverse to another, *e.g.*, at A, *Fig.* 19, the machine should make a wide turn, as shown in the figure, to give the observer about one minute to re-orient his board, change his ground speed scale, reset his stop-watch and be ready for work again on repassing A on the new course. To indicate his wish to the pilot the writer used to draw his attention to some prominent object vertically below the aeroplane and then circle the hand round the head. The meaning of the signal was of course explained to the pilot before leaving the ground. If this manœuvre is not carried out the observer will find—as the writer did in his early efforts—that the aeroplane is gaily sailing half-way down the next lap before he is ready to start work on the new course, resulting in a waste of time in explanations and in getting back once more to the initial point of the new course.

The sitting-down position while sketching is by no means an advantage and it would be far better if the platform on which the observer's feet rest were lowered to enable him to partially stand, supporting himself on a seat like a miserere seat in a cathedral choir-stall. The board should be raised sufficiently to enable him to use a light sight rule for re-section and cutting in or for interpolation work. Sights could be fitted to the ground speed scale rules for this purpose.

The canvas sides of the aeroplane should be cut away at the top to enable the observer to see well down on either side without having

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to crane his neck over the side, where he gets the full air blast which is very unpleasant. A sloping wind guard should be provided to protect his head. A dash-board is required for carrying watches, instruments, pencils, etc.; each observer must arrange these to suit himself, but he must leave plenty of room for his board to turn freely on its pivot.

In air survey, the best results would be obtained by two observers working together in one machine. No. 1 would carefully plot the course, both as to direction and distance, and would note everything affecting the ground speed, such as variations of wind, etc. He would at the same time plot or cut in any important points in order that No. 2's detail may be adjusted and fitted to these points. He should be nearest to the pilot and control the course. No. 2 would sketch in the detail and plot his course as far as he can without sacrificing the sketching in of important features. Detail is his special job.

It is easier to plot the course than to sketch in the detail. The latter work is a very severe test in England, where there is so much to be noted down. In complicated country it is almost impossible for one observer to record railway embankments, cuttings, bridges, stations, etc., as well as all the other detail such as that shown in No. 1 Sketch (*Plate* 3) at speeds of 80 miles per hour and over.

Salisbury-Winchester-Cowes-Christchurch Area Sketch.—This sketch is a copy of the actual survey made in the air. Only a few of the Railway Stations are shown. In some places the area is covered with a net-work of roads impossible to detail accurately in the time; these have been generalized, but many of the roads shown in the Ordnance Survey map (the ½ inch Winchester–Salisbury and Southampton) are disused, grass-grown, and can hardly be seen from the air. Others have sprung into existence since the war and several new villas appear to have been built, especially round the New Forest and in places like Chandler's Ford. In making this sketch no assistance was received from the Ordnance map except the names.

The base on which the work was done was a traverse from Winchester to Salisbury, which was originally made for another stretch. It was corrected for scale and traced on the working sketch. Traverses were run between Winchester and Christchurch, Christchurch and Salisbury, Salisbury and Cowes, Cowes to Winchester, Cowes to Christchurch, thence *via* Beaulieu to Calshott, and thence to Cowes, seven in all, and after being adjusted and corrected were traced on the field section. These took about 3½ hours' flight. Gridiron courses were then run all over the area, and the detail sketched in and inked up. Another trip was then made to fill in the blanks. The total time of actual work in the air was 9½ hours, and the area measured approximately 500 square miles. The fair map was then completed.

Plate 4, shows a simple route traverse. The conditions of work in this case are much like those obtaining in area work. The

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course should be carefully plotted and only important features cut in on the outward journey. On the return journey the rest of the detail can be filled in. Great care should be taken to note down anything that may affect the ground speed in order that the variance of the scale may be corrected as far as possible. If a larger board than 13″ by 13″ cannot be used the strip of paper for a route sketch will not exceed eight inches in width, and unless the pilot keeps a straight course from start to finish the traverse soon runs off the board and must be broken off and transferred to the opposite side.

In the survey of a route between two points the true bearing from starting point to destination must be known. This should be drawn down the centre of the paper and the pilot should be kept to this line throughout. Or a pilot may be directed to pass through several points to the destination, and if he knows his course it may be left to him, the observer merely keeping the course taken and shifting his work to the opposite side should he run off the board. But if there is any doubt, it is far better for the observer to retain the map, however small the scale, and control the course himself, but he must remember in this case that he cannot see the forward point, as he is seated facing backwards, and that he is responsible for arriving at each point in succession till he reaches his destination. In any case the responsibility that rests on the pilot must be made quite clear to him before starting, or the observer may find that he has completely lost his way. This actually happened to the writer on one occasion, and only the fact that he had previously been over the ground on foot, and recognized a town, enabled him ultimately to reach his destination before the petrol supply gave out. A strong cross wind was blowing at the time.

Work in Mesopotamia was a great deal simpler. Here it was comparatively easy to note down everything, keep the courses plotted and the board oriented, and cut in detail on either flank. It was possible to fly at 6,500 feet as the air was free from haze and one was seldom bothered by clouds, whereas in England it is rarely possible to fly above 4,000 feet, often much less.

Plate 2, which shows a sketch done from memory of ground similar to that surveyed by the writer before he was captured, is given as an example. The area was about 360 square miles and the time two hours.

By means of a reliable altimeter used in conjunction with a special form of clinometer it should be quite possible to deduce with fair accuracy (*a*) the ground distance between points on the earth's surface, and (*b*) ground speeds. Such data would be invaluable over unmapped areas when it is not considered advisable to land and carry out measurements on the ground.

The work in Hampshire was cut short by orders from the India Office and opportunities for carrying out further experiments were lost.

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Description of Instruments.

Compass Reflector for Air Survey Work (*see Figs.* 5—7, 13, 14).

This is used for orienting the sketching board by the aid of an aeroplane compass in cloudy weather or when the sun is momentarily obscured by a cloud. AB is a hollow tube telescoping into a similar tube and admitting of extension or contraction to suit the distance of the centre of the sketching board from the central line of the axis on which AB turns horizontally, *i.e.*, axis ab. AB is mounted in this manner to enable it to be swung to one side when not in use. F is the box containing the aeroplane compass which may be of any form suitable to this class of work. Both AB and F are fixed to brackets on the side of the aeroplane. The image of the N and S line of the compass card or " grid " is reflected in mirror G, which is fixed vertically above the compass and at an angle of 45° to the longer axis of AB. This mirror reflects the image on a small elliptical mirror H, parallel to G. H reflects the image through eye-piece I to the eye of the observer, who also sees, beyond the mirror opening K, the needle J on the sketching board vertically below it. J is a thin fine needle pivoted at O, the centre of the sketching board, set stiffly to prevent it shifting easily. With O as centre a small complete arc is struck to enable the angle subtended by J to be read, and the needle J reset if it gets disturbed while the board is being used for sketching. The theory of the instrument is shown in *Figs.* 13 and 14. The image of the N and S needle of the compass is reflected first on the mirror G and then on H, where it appears as A″ B″ (*see Fig.* 13). The eye at I sees this image on mirror H projected down on the sketching board as A″ B″, the limit of the mirror being shown by the dotted lines. Now if the needle J on the sketching board is set to represent the position of the compass needle when the board is truly oriented, all the observer has to do whenever the board is swung out of position by a change in the direction of the aeroplane is to turn it till the needle J coincides in direction with the reflected image of the compass needle, J being seen vertically below the eye and beyond the limit of the mirror H (*Fig.* 14). The determination of the correct position of J is a simple operation which need not be entered into here. The instrument is held in its place by a flexible metal arc xy (*see Figs.* 5 *and* 7) and a stud f (*Fig.* 5) which engages in one of the holes hh (*Fig.* 7) according as the instrument is in use or swung on one side when not required. The brackets M and N, supporting the instrument and compass, and the arc XY are mounted on a board capable of horizontal movement fore and aft (*see Fig.* 6) which is clamped into position by four strong wing nuts. This is necessary in order to make the complete set adaptable to any form of aeroplane.

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Ball and Socket Pillar Stand for Air Survey Sketching Board (*Figs.* 1 *to* 4).

The sketching board is fixed by four screws on boss A, which is fitted with a ball B held in a split cup CC. A spacing piece of suitable thickness, D, with a hole in the centre to take a bolt E, and of the same length as the diameter of H, with its ends rounded in section, is placed as shown in *Fig.* 2. The ball B is gripped in cup CC by means of bolt F, power being obtained by lever G (a wing nut would not provide sufficient power). A little grease should be rubbed on the ball. The spacing piece D keeps the inner faces of the neck HH' approximately parallel. H' is quite separate from H. H is fitted with a boss I, which is let in flush with the top of the wood pillar J and strongly screwed down to it, as shown in *Fig.* 1. Pillar J is cylindrical in section and can be moved up and down in clamp K, which is split along the line LL and can be tightened up by wing nut M. A copper L shaped split collar N is fitted, as shown in *Figs.* 1 *and* 4, to give a better grip—this fitting being found necessary in actual practice. Clamp K is fixed by two long bolts OO to a horizontal wooden transom (not shown) which has a hole in the centre through which pillar J can be raised or lowered. The shape of the transom depends upon the type of aeroplane to which it is fitted. The work of fitting can be easily done by any carpenter. This form of stand allows the sketching board to be levelled, turned on its pivot (*i.e.*, ball B) and raised or lowered at will.

Sketching Board.

(*a*) *For area work.*—A plain deal board with rounded corners and strengthened below by two battens; underneath the centre there is a wooden block into which the stand boss is fitted and screwed down. In size the board may vary from 9″ by 9″ to 24″ by 24″ according to type of aeroplane.

(*b*) *For traverse work* (*route traverses*) *see Figs.* 8 *to* 12 *and* 16.—The board is recessed at opposite ends to take the rollers AA. These must be set truly parallel to each other, or the paper strip rolled on them will not travel true. Each roller has a slit B into which the end of the paper strip is introduced before rolling, to give the necessary grip. A notched and milled wheel C, fixed firmly to the roller by screw D, enables the paper to be rolled up. Milling is not sufficient and notching is necessary to give the fingers sufficient grip, should the paper tend to roll stiffly. The roller must have a certain amount of stiffness to prevent the paper unrolling, and this is provided by a grip E and adjusting screw F. Stiff wax should be put between the bearing surfaces. Bearings GG are provided to take the roller, which is kept true by two screws HH which engage in small holes recessed in the centre of the solid end bosses of the hollow roller. All bearings should be waxed. The roller and its bearings are carried in a metal frame II, one end of which can be detached to assemble the mechanism. This frame is let into a recess in the board and

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screwed to it as shown. Two metal guides J, with packing pieces K, guide the paper between the rollers and prevent the high wind in the observer's compartment from getting under the paper and wrenching it off. Without the guides it would be impossible to keep the paper from being torn off its rollers. Underneath the board there are the usual battens L and wood boss M to take the metal boss of the pillar stand. Two small sun compasses are provided, one on either side, and are essential as the route survey must be kept up the centre of the paper, its mean inclination to the true N and S line being taken up by sun compass. This is effected by turning the N and S line of the latter through the angle which the route traverse makes with the N and S line on the earth's surface. The sun compass card after being turned through this angle is clamped by means of mill headed screw N which keeps it in the position set. There is a small vertical hole through the centre of N in which needle O is inserted to cast the shadow on the dial. With the same centre as N a complete arc is struck on the board for setting the compass card. Either compass can be used. The dial is not drawn on the paper as the latter is being constantly rolled off and on, and this would necessitate the dial needle being taken out and refixed each time. On the paper strip N and S lines must be drawn at, say, six-inch intervals parallel to the same line on the dials, in order to preserve the direction of the true north on the route traverse sketch. The centre of the sketch would normally coincide roughly with the centre line of the paper. Should the former deviate to the left or right, the dials must be turned through an angle in order to bring the centre line of the sketch parallel to the brass strips, and the centre line of the sketch must be shifted to the centre of the paper. The new direction of true north must be ruled up afresh on the paper, or the change in arc through which the compass dials are turned must be noted down at the point on the traverse at which the change takes place, so that the direction of true north may be drawn in on return to the aerodrome or landing place. It will be seen that the compass dials can be turned in order to keep the centre of the traverse line down the centre of the paper, which is a *sine quâ non* in route traverse work. Any length of paper can be mounted on the rollers provided the gap is not completely filled. It is best to use fine lithographic paper mounted on muslin as plain paper is apt to get torn.

Sun Compass.

This is based on the formulæ for Sun Azimuth —

$$\tan A \frac{\tan t \cos M}{\sin E - M} \text{ where } \tan M = \frac{\tan S}{\cos t}$$

A = Sun's Azimuth at time t.
t = hour angle before or after noon.
S = Sun's mean declination for the day.
E = Mean latitude of sketch.

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Having calculated the azimuth for the half-hours before and after noon, the dial can readily be prepared by means of a protractor. Azimuths at quarter hour intervals can be computed if required. Greenwich mean time is used, subject to the following corrections: (*a*) a correction (in functions of time) to allow for the difference in longitude between the centre of sketch and the former station and (*b*) a correction known as the equation of time, to reduce mean time to solar time. Then the N and S line points to true north when the shadow of the vertical needle in the centre of the dial cast by the sun coincides with the time shown by the watch corrected as directed above. *Fig.* 15 shows a normal dial. Two hours before noon and four after would be sufficient for normal working hours, except perhaps in a very hot climate when it might be advisable to start earlier and recommence work later in the afternoon, in which case additional hour angles can be computed and projected. The dials shown on the sketching board are approximately those which were originally employed and can be used for all parts of the compass.

On the area sketch a dial is drawn in each quarter square, as the body and the arm necessitate a shift when the aeroplane changes direction and the board conforms to this movement. The dial needle can easily and quickly be driven vertically into the board by means of a light wooden mallet. A lady's hat pin provided with a small metal ball on the top and cut to $3\frac{1}{2}$" makes a very good dial needle.

Clinometer for Air Survey work (*see Figs.* 20 *to* 23).

If the height above the ground is known the horizontal distance between any two points on the ground or the ground speed can be calculated by means of this instrument. Or given the ground speed or the distance between any two points on the ground, the height of the aeroplane above the ground can be calculated.

The instrument consists of a rectangular frame A B C D fitted to a yoke E F. The instrument is kept level by means of a striding level G, fixed to a bracket H which is fastened rigidly to E. E F is capable of turning on a butterfly nutted bolt I, which is fastened rigidly to a plate J, which in its turn is fixed to a slotpiece K, which slides into a groove in the bracket L. L is screwed to the side of the aeroplane. K is held in place by the stop pin M.

To correct any dislevelment of aeroplane in a fore and aft direction all that is necessary is to turn the instrument round the horizontal axis I till the bubble of G is in the centre of its run. The aeroplane must be kept on a straight course and at a constant height while readings are being taken.

The vanes N N are capable of sliding on the bars R R until either O, or O′ or O″ or O‴, as the case may be, coincides with the object to be cut in. There is a horizontal wire at P vertically above another

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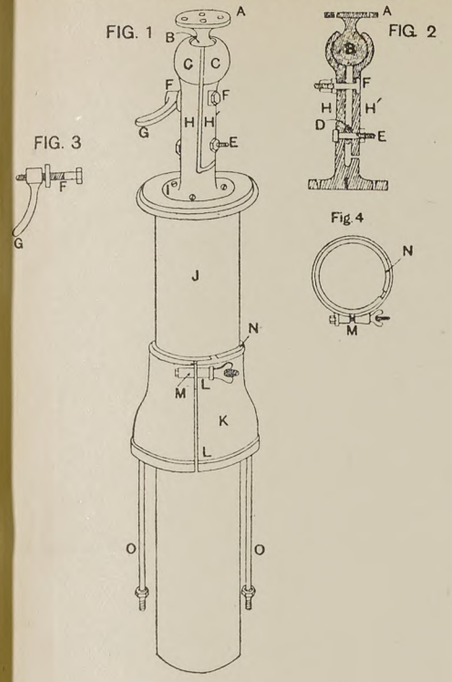
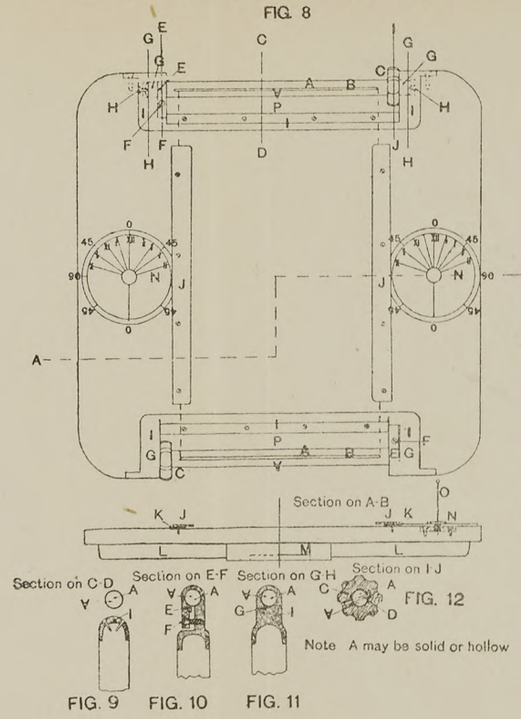
PLATE 1

Ball and Socket Pillar Stand for Air Survey Sketching Board

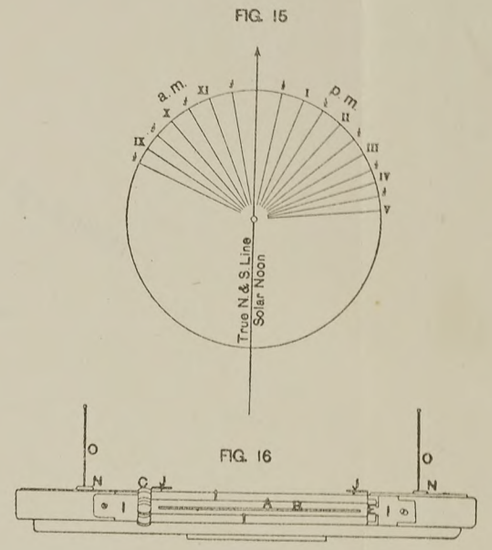


(b). Sketching board for air route traverse work



Sun Compass Dial

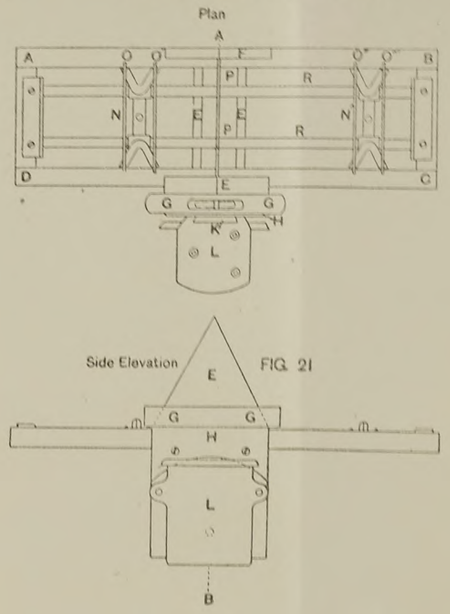
given
Latitude = 51° N approx
Sun's Declⁿ = 9° N
for ½ hour intervals



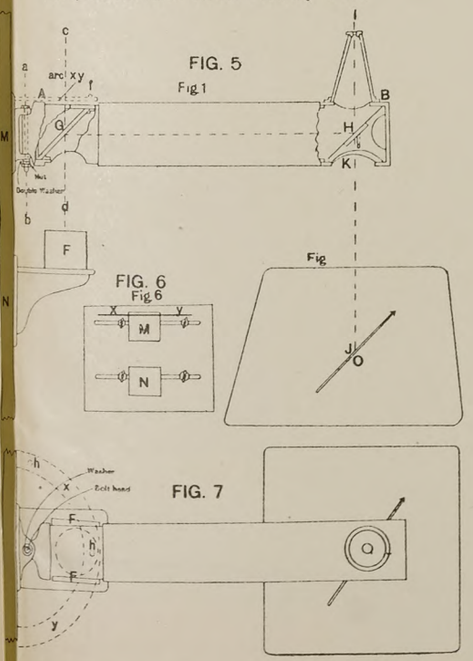
Side elevation of Sketching board vide FIG. 8

FIG. 20

Clinometer for Air Survey Work



Compass Reflector for Air - Survey Work



Compass Reflector for Air Survey Work

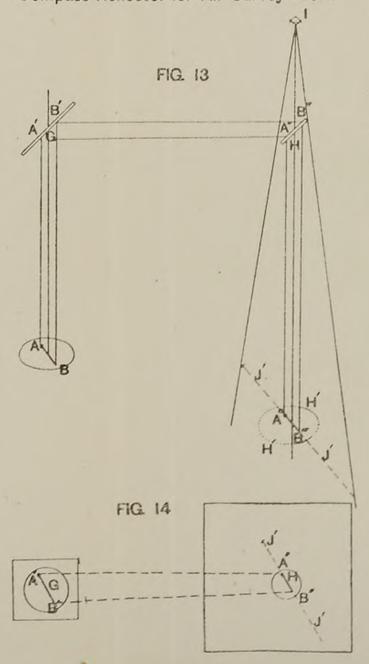


FIG. 17

FIG. 18

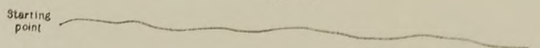


FIG. 19

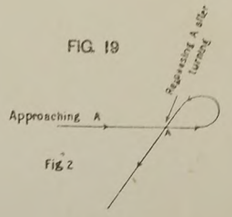
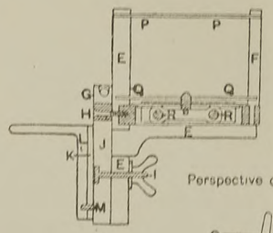


FIG. 22

Clinometer for Air Survey Work

Section on A-B



Perspective of sight-vane N or N

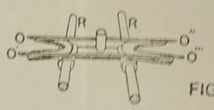
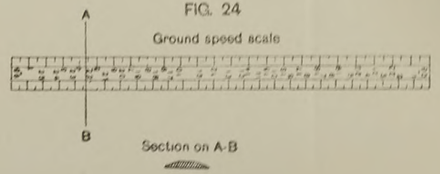


FIG. 23

FIG. 24

Ground speed scale



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at Q. Along A B and D C an arc is protracted with centre P P. Thus the angle between an object cut in by O, O′, O″ or O‴, and that of an object vertically below the alignment of P to Q can be measured, or the time it takes for an object to travel from position O or O′, O″ or O‴ to a vertical below P can be measured by means of a stop watch. By these means the data mentioned can be calculated.

In using N or N′ the object to be cut in is brought into line with P and O or O′, O″ or O‴.

Ground Speed Scales Fig. 24.—These are similar in shape to architects' scales, but not so wide—half-inch is sufficient —and they should not be longer than 10 to 14 inches. They can be used as sight rules and can be fitted with light sight rule sights—these are not shown in the *Fig.* A complete set of ground speed scales is required, from, say, 45 to 70 miles per hour, increasing by 2½ miles per hour, and from 70 to 130 miles per hour, increasing bv 5 miles per hour. Two scales go to one ruler.

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PROFESSIONAL NOTES.

ENGINEERING COURSE AT CAMBRIDGE UNIVERSITY.

ON the 7th October last Nos. 5 and 6 Supplementary Classes of young R.E. officers joined at Cambridge to undergo a one year's course of engineering. This constituted an altogether new departure in the technical training of the Army, which requires some words of explanation. During the war there was only time to give to newly-commissioned R.E. officers a short "war course" before they were posted to units, and so the arrival of Peace found a large number of officers who still lacked the theoretical training without which none can expect to become sound practical engineers. To deal with this number at Chatham in addition to the normal batches joining from the R.M.A. was a physical impossibility, and temporary outside assistance had to be sought. This was found in every sense at Cambridge, where, more than at any of the other great universities, instruction in Mechanical Sciences had been developed of recent years; and where at the head of the Engineering Laboratory was Professor Inglis, whose name had become during the war a household word in the Corps. Many difficulties, which need not be further specified here, had to be met; they were all overcome, and in due course the first batch was born, and is by now (to quote the Cambridge Pocket Diary) a sturdy infant.

The Mechanical Sciences Tripos.—The usual course for the Honours Degree takes three years. The first year is mainly spent in simple laboratory and drawing office work, and (if not done before leaving school) in passing the Previous Examination ("Little-go"). This is a general examination on somewhat similar lines to the entrance for Woolwich or Sandhurst. Exemption has been given during 1920 to those with war service, and various other examinations and certificates are accepted in lieu. There is also a "Qualifying Examination" in mathematics and mechanics, which must be passed before the end of their fourth term by all candidates for honours in engineering. This examination was specially designed to stem the flood, with which the Engineering Laboratory was at one time threatened, of undergraduates whose highest ambition was to learn how to repair their motor bicycles. It appears to fulfil its purpose. It is an important examination inasmuch as it represents the datum line from which the 2nd year course starts. The recent examination in December

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was taken by Nos. 5 and 6 Supplementary Classes, when 30 out of 50 qualified. This was a considerably higher percentage than among the general candidates, of whom only some 20 out of 75 qualified. It is possible that future supplementary classes will be called on to sit for the examination as soon as they arrive at Cambridge. The R.E. course of instruction is to consist of four terms and to embrace as much as possible of the 2nd and 3rd years' Tripos courses. Last term most of the work was done with the second year; it will gradually have to become more independent, whilst the fourth term will be devoted entirely to third year work. The work is for the most part theoretical, though a good deal of time is spent in the laboratories. There are heat, electrical, and structures laboratories, in each of which is a large variety of plant and machinery. Owing to the very great pressure on both time and space it is only possible to carry out standard tests and experiments, and every engineering student is expected to get practical experience by undergoing a course in commercial workshops, either during a long vacation, or after leaving Cambridge. This practical workshop training will be given to Supplementary Classes at Chatham after they leave Cambridge. The instruction is given in the form of lectures. Each main subject is taken by a separate lecturer, who is probably allowed two hours in the week. He delivers his lectures and departs, and there is neither time nor opportunity to ask questions; so difficulties have to be worried out from books or taken to the College Supervisor. Every College appoints one or more supervisors to look after their students at each school, but numbers are now so great that no student can hope for more than one hour weekly with his supervisor. The same remark applies to the R.E. officers, who are looked after by two specially appointed supervisors instead of getting tuition in College. Many candidates for honours find it necessary to get private coaching, for which they make their own arrangements, and of course have to pay.

The University Year only really lasts 8 months—from October to June, and consists of three terms, each *full* term, during which lectures are given, only lasting about 8 weeks. In addition there is a more or less regular "Long Vacation" term in July and August lasting about 6 weeks, which is attended by most candidates for honours, and during which a regular course of lectures is given at the Engineering Laboratory. This will form the fourth term of the R.E. course. Although these terms sound remarkably short enough has probably been said to make it clear that few can hope to take honours without working just as steadily through the vacations as through the terms. It is in fact during vacation time that most solid learning has to be done. There simply is not time for it during term. It is perhaps unnecessary to add that learning does not fill the whole of life at the University. There is a quite unparalleled variety of other occupa-

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tions to be selected from. Games of every kind and description, sport, music, art, literature, politics—all are provided for—and he must have strange hobbies who cannot find means of indulging them at Cambridge.

College Life.—There are 18 Colleges, at each of which are 2 to 4 R.E. officers. Every College is an independent republic, and so expenses and customs vary to some extent at each one of them. There are many handbooks that give full information about the Colleges, and it is not proposed to give more here. R.E. officers are in exactly the same position in College as other students. They are subject to all College and University discipline, wear cap and gown, and are in fact undistinguishable from ordinary undergraduates. In this way they have the fullest chance of joining in College life, whilst the College authorities appreciate the subordination to their authority, and are the more inclined to look favourably on a scheme, which, from their side, has no great advantages. 1,500 Freshmen came up last term, and the total number at the University is not far from double the highest pre-war figure. Every College has a long waiting list, and it was no small concession on their part to admit temporary one-year students to these much sought-after vacancies.

MODERN TENDENCIES IN MARRIED QUARTER DESIGN.

THE housing question is one of the greatest problems which the nation has to face at the present time, and the army's share in this is by no means the least of the problems before the Chief Engineers of all Commands. The provision of married quarters for the rank and file is a part only of the housing of the Army, but—with married quarters for officers—it is the matter in which, of all works questions, supply falls furthest short of demand.

The publications of the Ministry of Health lay down for the first time what may be called a " Synopsis scale " for the housing of the nation, and it is well to realize the points in which the army's needs differ from those of the nation at large. The married soldier should clearly be as well housed as his relative in civil life, and in fact, where the 1911 Barrack Synopsis has been followed, he is actually far better housed than the average of the nation at present. This cardinal difference exists between the civilian and the soldier, that while the former may live in the same house all his married life, the soldier except in rare cases lives no more than 5 years in the same quarter ; and these years are normally the earliest of his married life There is therefore little objection to temporary or hutted married quarters—and indeed there is no possibility of funds being available for years to build permanent quarters on a large scale. Further, the number of soldiers' families with more than one or two

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children will always be small. The proportion of "a," "b," and "c" (one, two, and three-bedroom) quarters is laid down in the 1911 Synopsis as, roughly, 55 to 35 to 10, and it is not likely that this scale will be varied in any way. The "a" quarter is fully large enough for the married soldier until the second child arrives or the first grows out of infancy; and this must normally mean a period of at least 2 years after marriage.

With this exception, there is no doubt that but for the war the Synopsis scale would have risen by this time to that of the Ministry of Health's non-parlour type of cottage. Shortage of funds may compel us in some cases to work to a slightly lower standard, but it is obvious that the shorter the funds the greater the need for skill and care in planning to ensure maximum comfort at minimum expense.

The sizes of rooms laid down in the 1911 Synopsis are adequate. It is a counsel of perfection that all rooms should open on to a lobby or passage. With care, this is attainable without undue expense in the great majority of plans, and only where the site is extremely restricted should the designer be satisfied with any arrangement of rooms opening off each other. Nothing wastes the available space in a room so badly as doors. In a certain very new housing scheme (for which the War Department is not responsible) some living rooms of 140 feet super have three doors—one leading to the entrance lobby and two to bedrooms which have no other doors. The working and living space in these rooms is thus reduced to about 80 feet super. Still worse, in fact quite inadmissable, is a bedroom opening off another. The objections to this are obvious and need not be laboured. Bedrooms should never be designed without consideration of the position of the bed. In the main bedroom a 4′ 6″ bed and a small cot should be legislated for. In many small bedrooms the fireplace is so sited as to prevent a bed being placed along the wall on the fireplace side; a very small movement of the fireplace would have put matters right, but this never entered the head of the designer.

Whether cooking should normally be done in the living room or the scullery is a question still under discussion. Under the present scale of fuel allowance the soldier cannot afford more than one fire, and this fire must therefore cook his meals. During the winter the same fire must warm the quarter, and hence its proper place is the living room. During the summer, however, a fire in the living room is naturally objectionable, and it is desirable to confine cooking operations to the scullery. There are two ways of solving the problem which obviously presents itself. The first, which is the cheapest for the soldier, is the provision of a grate of a pattern like the double "Servall." This is only possible when the living room and scullery are back to back and separated by a partition wall. The double

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" Servall " grate provides a fire in each room and has a single oven above the fires with doors into each room. It is possible therefore in winter to light the fire in the living room and by its heat to do all the cooking operations which necessitate the use of the oven in the scullery. In summer the fire can be lighted on the scullery side. The " Servall " grate unfortunately is rather costly and at present difficult to obtain; also, the planning of most existing quarters makes the arrangement impossible. The second solution of the problem consists on the provision of an ordinary small cooking range with open fire in the living room and a gas cooker with penny-in-the-slot meter in the scullery. The objection to this is that in winter cooking cannot be confined to the scullery unless the soldier is able to bear the cost of a coal fire in the living room, plus the gas required for cooking.

Another factor in the problem has not been mentioned; the conservative tendency of many families to eat in the room in which the food is cooked. No doubt this saves the housewife trouble in the carrying of food and crockery. It has led to the suggestion that the normal quarter should be designed with a roomy kitchen-scullery and a small living room. Whatever the views of the lady of the house on this arrangement might be, there is little doubt that it would mean a most uncomfortable quarter for the soldier. The living room would degenerate into a " Parlour " and would not be " lived in " ; and the soldier would have to spend his time at home amid the operations of a scullery, which are distinctly unpleasant to live with. If cooking is to be done in the scullery therefore the latter should be just large enough for its purpose and not large enough to take a dining table as well.

The question of washing and sanitary arrangements next calls for comment. Whether there is a laundry provided outside for the use of the married women or not, there should be within each quarter facilities for the washing of clothes. Such facilities must include arrangements for boiling and rinsing the clothes. For the boiling process, a copper is required; for the rinsing, a bath is suitable. Apart therefore from the question of personal ablutions, a bath of sorts is undoubtedly desirable. In the Synopsis a copper and a sitz bath in the scullery are included, and this arrangement, though not ideal, meets the actual needs of the case; and if the scullery is large enough to take a bath there is no justification under present conditions for departing from this ruling. The provision of a slipper bath of a small size—4′ 6″—may be authorized in new quarters, and the placing of it in a separate room, where circumstances permit, undoubtedly makes it far more useful for personal use. The laying-on of hot water from a h.p. boiler, involving as it does expensive plumbing and constant trouble in maintenance, under present conditions cannot be considered, and hot water for the bath must be

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normally obtained from the copper. From every point of view therefore the bath must be close to the copper, and it may be possible and advantageous sometimes to put both the copper and bath in a separate small " washing-room," in which there should also be some sort of washing tub—a deep sink is suitable. If gas is provided for cooking in the scullery, the copper may be gas-heated.

The W.C. must on no account open off the scullery or living room or be adjacent to the larder, without the interposition of a properly ventilated lobby. If a separate bathroom be provided, it may be necessary to put the W.C. apparatus in it, and this sometimes saves expense in water supply pipes. It is however an inconvenient arrangement, inadmissable if the bathroom is designed as a wash-house, and can generally be avoided by careful planning.

The larder may be a small ventilated cupboard, and there is no great disadvantage in its opening off the living room or scullery, provided that it is not near the heat of the cooking stove, and that the convenience of the rooms is not prejudiced by the presence of the larder door. The coal cupboard can be smaller than is usual in civil life as the married soldier receives a weekly ration. There should if possible be a recess on the ground floor capable of taking a bicycle and perambulator. Stairs should be well lit, winders should be avoided if possible and in any case not inserted at the top of flights.

The above remarks may it is thought, be of use to officers who have to design new married quarters whether in new construction or in converted hutting. The adoption however of some of the counsels of perfection given, in temporary buildings, or in existing married quarters, must be governed not only by the availability of funds but also by consideration whether the buildings are structurally worthy of detailed improvements.

NOTES ON MILITARY BRIDGING.

1.—A great deal of discussion and a certain amount of experimental work has been carried out on military bridging during the last two years, and the whole subject needs now to be reviewed.

2.—Military bridging can be divided into four phases :—

(*a*).—The construction of a bridge to enable infantry to fight their way across an obstacle which is closely defended by the enemy.

(*b*).—The construction of a bridge to enable field guns and first line transport (light loads) to cross an obstacle which is under shell fire.

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(*c*).—The construction of a bridge to enable lorries and the 6-inch howitzer and 60-pndr. gun (medium loads) to cross an obstacle.

(*d*).—The construction of main road bridges to take siege artillery and the heaviest military traffic.

It is only proposed in this paper to discuss bridging equipment and to leave out the whole question of improvised bridges. In this way we are at once reduced to two types—the service pontoon equipment, and stock span girder bridges. The former will be taken first.

3.—As regards (*a*) it is generally agreed that a light floating bridge (of the cork float type) fills our requirements. The old idea of a bridge of half sections of pontoons is too heavy and cumbersome for use under fire. A light floating bridge of this nature requires to be standardized. Many different types were used during the latter part of the war. Some were better than others, but they were all capable of improvement. An inferior design may cost the lives of many officers and men and we should not be satisfied with any but the very best possible design.

4.—As regards paras. (*b*), (*c*) and (*d*) we know at the moment that we can produce satisfactory bridges to fulfil our requirements in the following three ways :—

(1).—By constructing a light bridge by using decked-in pontoons at 15 feet intervals and a superstructure of bridging baulks and single chessing.

(2).—By constructing a medium bridge with piers which consist of six half sections of decked pontoons and 21ft. steel joists with double chessings.

(3).—By constructing a heavy bridge with piers which consist of eight half sections of decked pontoons and 21ft. steel joists with treble chessing.

We must now discuss the methods by which we can obtain the full use from these three bridges ; then when we have collected our ideas as to their correct use we can proceed to discuss the more detailed designs of these three bridges.

5.—Now the suggested method of using these bridges can best be illustrated by examples :—

The infantry have forced their way across a river but are hard pressed and require field artillery support. The river is under heavy shell fire and the construction of a bridge will be a difficult undertaking. The lightest and best possible pontoon equipment which will carry field guns is required. For this work a pontoon equipment in its present form or something very like it is necessary. We will now take another example. The infantry have crossed a river and are driving the enemy back rapidly. The river is not under heavy shell fire, and will probably soon be out of range of the enemy's field guns. There is a demolished bridge on the main road across

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the river. In this case the river should at once be bridged at this point with a pontoon bridge to carry medium loads, for it is obvious that lorries will want to cross this river at the earliest possible moment. In some cases a light bridge will be built first and converted later to a medium bridge, but as a rule if light bridges are built first to take the field guns they should be constructed clear of the main roads. The medium bridge can then be built without interfering with the passage of artillery wagons over the light bridge. If there should be a shortage of pontoons the light bridge can be broken up at the last moment to form the last few piers in the medium bridge. In many cases no light bridges would be built at all and the first bridge put across the river would be a medium bridge. The difference in the time required for the construction of a light and medium pontoon bridge will not be great. A river such as the Aisne at Soissons may be taken as an average case and is about 200ft. wide; and the difference in bridging this river for light and medium loads would probably not be more than one hour. It is true that much more material and transport is required to bridge such a river for medium loads than light loads, but the total amount is small in either case. Fifteen lorries with trailers would be sufficient to bring up the equipment for a medium bridge across this river.

6.—The light bridges built with pontoon equipment should therefore be considered as emergency or fighting bridges. The approaches would not as a rule be required to be timbered or made good because the bridge should only be in use for a short time, and the site of these bridges might often be chosen from tactical reasons rather than from a point of view of their proximity to a road, or suitability of the approaches, etc. The equipment for the construction of these bridges would be drawn from the Divisional Bridging Train; it would be taken as far as possible by lorry, but might require to be horse-drawn to the site of the bridge.

7.—The equipment for the medium bridges should be sent up from the Corps Bridging Train, being supplemented if necessary by the Divisional pontoons.

8.—In colonial warfare the light bridges might be of comparatively greater importance, but the use of lorries and construction of main roads is extending rapidly to the colonies. Moreover, the field artillery and first line transport may become tractor drawn, in which case a bridge for light loads will probably cease to be required.

9.—As regards sub para. (*d*) in para. 2 we have seen that a bridge to take heavy loads can be constructed from the service pontoons (decked-in) by using piers of eight half sections and eight steel joists. In European warfare when the siege artillery may be close up with the field army, it might be desired to build a heavy bridge straight away instead of a medium bridge. As a rule a comparatively small number of heavy bridges would suffice; for instance on a front of

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three miles we might find say three medium bridges and one heavy bridge, some or all of which might be replaced later with girder bridges. In colonial warfare and even at times in a European war the army might advance purely as a field army without siege artillery, and medium bridges might cover all requirements.

10.—The present service equipment includes a bridging trestle—the Weldon Trestle. This trestle is required in connection with the pontoon equipment for the following work.

(*a*).—For use in tidal ramps.

(*b*).—To save the risk of damaging pontoons by grounding on a hard bottom near the banks.

(*c*).—For use over swampy ground on the approach to the bridge.

(*d*).—For crossing dry gaps or craters on roads.

In pre-war days when the old medium bridge (present light bridge) was the main military bridge there was every reason to retain the Weldon Trestle for the work indicated above; but now that this bridge is an emergency bridge the necessity for the Weldon Trestle is far less apparent. If the water is shallow near the banks and the end pontoon grounds, it may be damaged, but the bridge will not fail (especially with the new decked-in pontoon which is considerably stronger in this respect) and when constructing a fighting bridge the risk of damaging a pontoon is of small importance compared with the loss of time in erecting a Weldon Trestle.

During the war Weldon Trestles were used on many occasions as indicated in (*d*), but for this work it seems eminently desirable to erect a trestle which will carry medium loads.

Now a new trestle has recently been designed of steel which weighs 40% more than the Weldon Trestle but will carry medium loads (the Weldon Trestle will only carry light loads). This trestle is quicker in erection than the Weldon Trestle, and it is now suggested that this trestle should be adopted instead of the Weldon. It would rarely be used with a light bridge, but would be of great value for medium bridges, and a tower built of two of these trestles would serve to carry heavy loads.*

11.—As regards girder bridges, a large number of types were evolved during the war, but with two exceptions they all aimed at carrying the heaviest loads over spans which varied in length up to some 150ft. The two exceptions were the Inglis light and Inglis heavy pyramid bridges. Now a conference was held at Chatham in August, 1920, to consider the retention of the various bridges. The Inglis light pyramid bridge was considered worth retention to assist in the first phases of an advance. The Inglis heavy pyramid was

* *Note.*—This trestle was described in the January, 1921, number of *R.E.J.*

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not considered worth retention. Of the various remaining girder bridges it was found necessary to recommend the retention of five different types and the introduction of a further light girder bridge for medium loads. Since that date, a new type of girder bridge (the box girder) has been designed, which may replace all the shorter stock span girders and this bridge is adaptable to carry any desired load (light, medium, or heavy). In a few months' time we shall know considerably more about the possibility of girder bridging in this manner and it is therefore not proposed to discuss girder bridges any further in this paper.

12.—We can now consider the detail design of the three types of pontoon bridge enumerated in the first part of para. 4. It is generally agreed that it is important to have the simplest possible type of pontoon equipment in which every part is inter-changeable and adaptable and which contains as few separate and different parts as possible. The decked in pontoon appears to be desirable in almost every way. By using decking the available buoyancy is almost doubled, and the pontoon remains quite easy to row. The swamping of a pontoon by the water rushing over the bows in a swift stream is rendered impossible. The additional weight is 600lbs. per complete pontoon at present, but this can be reduced—probably to about 400lbs. (or even less). If this can be done the decked-in pontoon appears to be quite satisfactory for all three types of bridge. It has been pointed out that the half pontoon is no longer required and that the service pontoon should be made in one piece. This however has the following disadvantages :—

(1).—A pier of six half sections cannot be made.

(2).—If one end of a pontoon is smashed the whole pontoon is rendered useless for the time being.

It would therefore appear to be desirable to retain the bipartite pontoon. In fact the present pontoon, if decked-in and fitted with strengthened couplings will provide a very satisfactory pontoon for every type of pontoon bridge.

13.—As regards the light bridge it has been urged that the bay should be made 21ft. instead of 15ft. so as to simplify the changing from light bridge to medium bridge. Now the light bridge carries a 2-ton axle load and if it were a matter of strengthening this bridge to carry a 3-ton or 4-ton axle load, it might be possible to carry out the work with little or no obstruction to the traffic. We have however to increase the strength of the bridge four times, *i.e.*, to take an 8-ton axle load. It is therefore out of the question to do this without obstructing the traffic, but can we introduce any system whereby the change over will be very rapid, so as to cause the least possible obstruction to the traffic ? A suggestion has been made that the light bridge should consist of 21ft. bays and piers of two pontoons side

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by side. This however is not recommended for the following reasons :—

(1).—The construction of the light bridge would become a slower operation and therefore much more difficult under fire.

(2).—It is doubtful if the process of changing bay by bay from light bridge to medium bridge would be of any great advantage. On a river which was 200ft. wide the whole operation of changing from light bridge to medium bridge could be carried out in one hour by breaking up the light bridge entirely and rebuilding as a medium bridge.

(3).—In most cases the light bridge (if built at all) should be constructed clear of the site for the medium bridge, and this problem would not arise.

14.—A continuous girder has been designed by Major Inglis for use with the pontoon equipment and will be tested in some six months' time. This will probably provide a very good main road bridge for wide rivers, but will hardly fill our requirements for hasty pontoon medium bridging over average size rivers in a rapid advance. It is possible that the box girder design may be satisfactory as a continuous girder in the Inglis pattern bridge. The decked in pontoon will be very suitable for use under a continuous girder.

15.—In the equipment which has been tested at Christchurch the following are the only parts required for any of the three bridges.

(1).—Decked-in pontoon.
(2).—Existing pattern pontoon saddle.
(3).—Existing pattern bridging baulks.
(4).—Existing pattern chesses.
(5).—Existing pattern ribands.
(6).—New design of short baulk.
(7).—New design of steel joist saddle.
(8).—New design of steel joist road-bearer.
(9).—New design of steel kerb.
(10).—New design of trestle.
(11).—The existing pattern accessories such as anchors, cables, etc.

It is thought that when certain detail improvements have been made and the weight of the decked pontoon reduced, this equipment should fulfil all the requirements of the Army.

16.—There remains the question as to how and where the pontoon equipment should be carried. In the eventual future the transport of an Army will no doubt travel on tracks, but for the moment we must keep to lorries and horses. The following is therefore suggested :—

(*a*).—The Divisional Bridging Train should carry light bridge equipment only (but pontoons decked-in) ; the equipment to be

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carried in a strengthened type of pontoon or trestle wagon towed behind a lorry, but capable of being horse-drawn when necessary. The lorries themselves to carry a bridge equipment of the cork float bridge type. In this way the Division will be always prepared to meet any emergency with its own bridging equipment.

(*b*).—The Corps Bridging Train to carry pontoons and superstructure for medium bridge (this is also suitable for a shorter length of heavy bridge) and a small reserve of timber baulks for the light bridge. Also a small reserve of the cork float type of bridge. Medium bridge pontoon equipment would be sent up to Divisions as and when required.

(*c*).—Army Bridging Parks and Engineer Stores would hold reserves of every form of pontoon equipment, girder bridges, and bridging stores. Any girder bridges could be sent up by lorry to the Corps or Division when required.

17.—To sum up therefore the following are the recommendations made in this paper:—

(*a*).—Further detail experiments to be carried out to reduce the weight of the decked pontoon and if successful that this type of pontoon should become universal.

(*b*).—The pontoon equipment as tested at Christchurch to be standardized after further trials (and possibly minor detail alterations) as the pontoon equipment for the Army.

(*c*).—That a floating bridge of the cork float type (but not necessarily cork) be standardized.

(*d*).—That the Divisional Bridging Train should carry light pontoon bridge equipment in trailers behind lorries. The trailers to take the form of strengthened pontoon wagons capable of being horsed. Also that these lorries should carry the standardized cork float bridges.

(*e*).—The Corps Bridging Train to carry medium bridge pontoon equipment and the new type steel trestle on the same type of trailer as used in the Divisional Train. This equipment will build up into a shorter length of heavy bridge as desired.

(*f*).—The question of girder bridges to be reviewed later when we know more about the possibilities of the box girder bridge.

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BOOKS ON CIVIL ENGINEERING.

(Continued from January).

7. FOUNDATIONS (INCLUDING FOUNDATIONS FOR MACHINERY).

FOUNDATIONS AND MACHINERY FIXING.—By F. H. Davies, A.M.I.E.E. Published by Constable and Co. Price 2/-.

Deals with the Design and Construction of Foundations for Machinery of various types.

Chapters I. and II., Foundations Generally. Chapter III., Design, The Proportion of Foundations for Engines, Turbines, and Dynamos. Chapter IV., Materials for Foundations. Chapter V., Holding-down Bolts and Anchor Plates. Chapters VI. and VII., Practical Construction. Chapter VIII., Vibration, its causes and effects. Chapter IX., Methods of Isolating Machinery, to prevent the Vibration affecting the neighbourhood. Chapter X., Fixing of Electric Motors.

A PRACTICAL TREATISE ON FOUNDATIONS.—By W. M. Patton, C.E., formerly Professor of Engineering at the Virginia Military Institute. Second edition. Published by Chapman and Hall, Ltd. Price 23/-.

A comprehensive work explaining fully the Principles involved, and containing descriptions of all the most recent structures with numerous drawings.

An accurate record of the Bearing Resistances of Materials as determined from the Loads of actual Structures is included.

Contents :—Part I.—Foundation Beds. Foundations. Concrete. Building Stones. Quarrying. Stereotomy. Masonry. String Courses and Coping. Ice and Wind Pressure. Retaining Walls. Arches. Skew Arches. Brick. Brick Arches. Box Culverts. Cements and Hydraulic Limes. Mortar. Sand. Stability of Piers. Water way in Culverts. Arch Culverts. Cost of Work. Dimensions. Quantities and Cost. Definitions and Tables.

Contents :—Part II.—Timber Foundations. Coffer Dams of Timber. Open Caissons. Cushing Cylinder Piers. Sounding and Borings. Timber Piers. Framed Trestles. Properties of Timber. Durability of Timber. Preservation of Timber. Joints and Fastenings. Trestle Foundations. Timber Piles. Piles. Comparative Estimates of Costs of Framed and Pile Trestles. Embankment of Earth on Swamps.

Contents :—Part III.—Deep and Difficult Foundations. Pneumatic Caissons. Caisson Sinking. Combined Crib and Caisson. All Iron Piers. Location of Piers. Poctsch Freezing Process. Quicksand. Foundations for High Buildings. High Buildings.

8. MASONRY STRUCTURES.

EARTH PRESSURES, WALLS AND BINS.—By W. Cain. Published by Chapman and Hall. 13/6.

Chapter I., Laws of Friction and Cohesion ; Tables ; Direction and Distribution of Stress. Chapter II., Thrusts of Non-cohesent Earth ; Graphical Methods. Chapter III., Analytical Methods. Chapter IV., Design of Retaining Walls of Stone or Reinforced Concrete. Chapter V., Cohesent Earth. Chapter VI., Bin Theory.

A TREATISE ON MASONRY CONSTRUCTION.—By I. Baker. Published by Chapman and Hall. 25/-.

Deals very completely with the subject.

Part I., Materials. Part II., Preparing and Using the Materials. Part III., Foundations, Ordinary, Pile and Under Water. Part IV., Dams, Retaining Walls, Bridge Abutments and Piers, Culverts and Masonry Arches.

Appendix I.—Specifications.

Appendix II.—Supplementary Notes.

9. CONCRETE AND REINFORCED CONCRETE.

MANUAL OF REINFORCED CONCRETE AND CONCRETE BLOCK CONSTRUCTION.—By C. F. Marsh, M.I.C.E., and W. Dunn, F.R.I.B.A. Published by Constable and Co., London. 1 vol. ; 8vo. ; pocket size ; 3rd edition ; 1916. Price 10/6.

Part I., Materials. Part II., Construction. Part III., Waterproofing and Fire Resistance. Part IV., Loads, Bending Moments, etc. Part V., Calculations. Part VI., Hollow Concrete Blocks. Part VII., Tables, Diagrams, and General Information.

Gives in handy form the methods employed for the solution of everyday problems,

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with the information most frequently required in as condensed form as possible consistent with clearness. Demonstration and reasoning upon which formulæ are based are mostly omitted. Practical construction is fully dealt with. There are numerous labour-saving tables. Strongly recommended.

CONCISE TREATISE ON REINFORCED CONCRETE.—A companion to "The Reinforced Concrete Manual." By C. F. Marsh, M.I.C.E., and W. Dunn, F.R.I.B.A. Published by Constable and Co., London. 1 vol.; 8 vo.; 1909. Price 7/6.

Chapter I., Properties. Chapter II., Behaviour under Loading. Chapter III., Assumptions for Calculation. Chapter IV., Methods of Calculation. Chapter V., Methods of Reinforcement.

This supplements the "Manual," matters dealt with there being mostly omitted from this book, while the derivation of fundamental formulæ is fully explained.

CONCRETE ENGINEERS' HANDBOOK.—Data for the Design and Construction of Plain and Reinforced Concrete Structures.—By G. A. Hool, N. C. Johnson, and S. C. Hollister. Published by McGraw-Hill Book Co., New York (Hill Publishing Co., London). 1 vol.; 8 vo.; 1918. Price 25/-.

CONCRETE, PLAIN AND REINFORCED.—By Taylor and Thompson. Published by Chapman and Hall, Ltd. 27/6.

Deals with the Materials, Construction, and Design of Concrete and Reinforced Concrete.

Chapter I., Essential Elements. Data on Handling Concrete Labour, Costs of Hand Mixing, Weights and Volumes. Chapter II., Selection of Materials, Proportions, Quantities, Tools and Apparatus, Construction of Forms, Mixing and Laying, Cost and Strength of Concrete. Chapter III., Specification for Reinforced Concrete. Chapter IV., Classification of Cements. Chapter V., Chemistry of Hydraulic Cements. Chapter VI., Specification of Tests of Cement. Chapter VII., Tests of Aggregate. Chapter VIII., Voids and other Characteristics of Concrete Aggregates. Chapter IX., Strength of Composition of Cement Mortar. Chapter X., Preparation of Materials for Concrete. Chapter XI., Tables of Quantities. Chapter XII., Preparation of Concrete. Chapter XIII., Mixing Concrete. Chapter XIV., Depositing Concrete Chapter XV., Effect of Sea-water. Chapter XVI., Laying Concrete during Frost. Chapter XVII., Destructive Agencies. Chapter XVIII., Water Tightness. Chapter XIX., Strength of Plain Concrete. Chapter XX., Theory of Reinforced Concrete. Chapter XXI., Tests of Reinforced Concrete. Chapter XXII., Design. Chapter XXIII., Building Construction. Chapter XXIV., Foundations of Piers. Chapter XXV., Beam Bridges. Chapter XXVI., Arches. Chapter XXVII., Dams and Retaining Walls. Chapter XXVIII., Conduits of Tunnels. Chapter XXIX., Reservoirs and Tanks. Chapter XXX., Pavements and Side-walks. Chapter XXXI., Cement Manufacture.

This book is especially valuable, but the Methods of Design of Reinforced Concrete, given in Chapter XXII. are not of such universal application as those given by Marsh and Dunn in their Manual of Reinforced Concrete. The author very clearly explains in Chapters XX. and XXI. certain valuable information of Tests of Reinforced Concrete.

REINFORCED CONCRETE CONSTRUCTION, PART I.—By M. T. Cantell. Published by Spon and Co., 5/-.

A somewhat elementary, but excellent little book, giving a full table of formulæ and 30 worked out examples of columns, singly and doubly reinforced beams and T Beams.

ELEMENTARY PRINCIPLES OF REINFORCED CONCRETE CONSTRUCTION.—By Ewart S. Andrews. 2nd edition. 1918. Published by Scott, Greenwood and Son. Price 5/5.

This little book of 200 pages is Vol. 1 of the "Broadway Engineering Handbooks."

From the principles of Applied Mechanics, the author evolves the fundamental equations connecting the Moment of Resistance of R.C. Beams with their size and the amount and position of the enclosed steel.

These equations are the basis of all the graphs given by modern English writers. Rectangular Beams, singly and doubly reinforced, and T beams are dealt with. A Chapter on Combined Bending and Axial thrust will be found useful in considering the stability of a small R.C. arch that does not require the Elastic Theory. Shear is rather sketchily dealt with. Columns, both simple and jacketted, are dealt with in the usual way. 25 Exercises are given at the end, but there are several printer's errors in the answers.

Appendix I. gives the Reinforced Concrete Regulations of the London County Council.

Appendix II., Numerical Tables, Logarithms, Trigonometrical functions, Squares, Cubes, etc. Areas of Circles, Metric Equivalents, Areas of Grouped Bars.

(To be continued).

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MEMOIR.

SIR W. de W. ABNEY, K.C.B., D.Sc., F.R.S.

BY the death on December 2nd, 1920, of Sir William Abney there passed away at the age of 77 one of the notable figures of the scientific world of the past forty years, and one whom the Corps of Royal Engineers can fairly claim as her own. Though he held rank as an R.E. officer only for twenty years, retiring as a Captain at the early age of 38, he never lost the sense of comradeship with and affection for the Corps and always took pleasure and pride in the fact that he belonged to it. In truth his retirement hardly severed his active connection with it. The department of Science and Art, which he had by then entered and to which the whole of his official life was thenceforward devoted, was manned nearly exclusively by R.E. officers, so that it was in effect almost a branch of the Corps devoted to civil administration. When the present organization of the Board of Education was set up in 1903 this department was abolished, and Abney, the last survivor of the R.E. staff, who had by then been promoted by successive steps to the post of Principal Assistant Secretary in the Board of Education, found himself compelled to retire, serving afterwards, up to the time of his death, in the honorary capacity of Scientific Adviser to the Board. His official career was, however, even to himself, the unimportant side of his life; what he will be remembered as, and what he himself would wish to be remembered as, is as one of the great pioneers in the sciences of photography, light and colour vision. It would be inappropriate here to undertake any detailed review of his work, but a short summary of it will not be out of place.

Abney most markedly had the true scientific spirit, the determination to know and the wish to improve, and everything he touched was imbued with this spirit. He was born in 1843 and entered the Corps through the Royal Academy in 1861. The first ten years of his service spent in part in India were uneventful. In 1871 he was appointed to the staff of the School of Military Engineering as Assistant Instructor in Telegraphy, and was given charge of a very small photographic establishment and a chemical laboratory, then constituting part of the Electrical School.

He now found himself in a position to take up original work and his first scientific paper "On Electrical Pyrometry" appeared in the Philosophical Magazine for 1872. It was however to photography that his chief attention was directed. He at once

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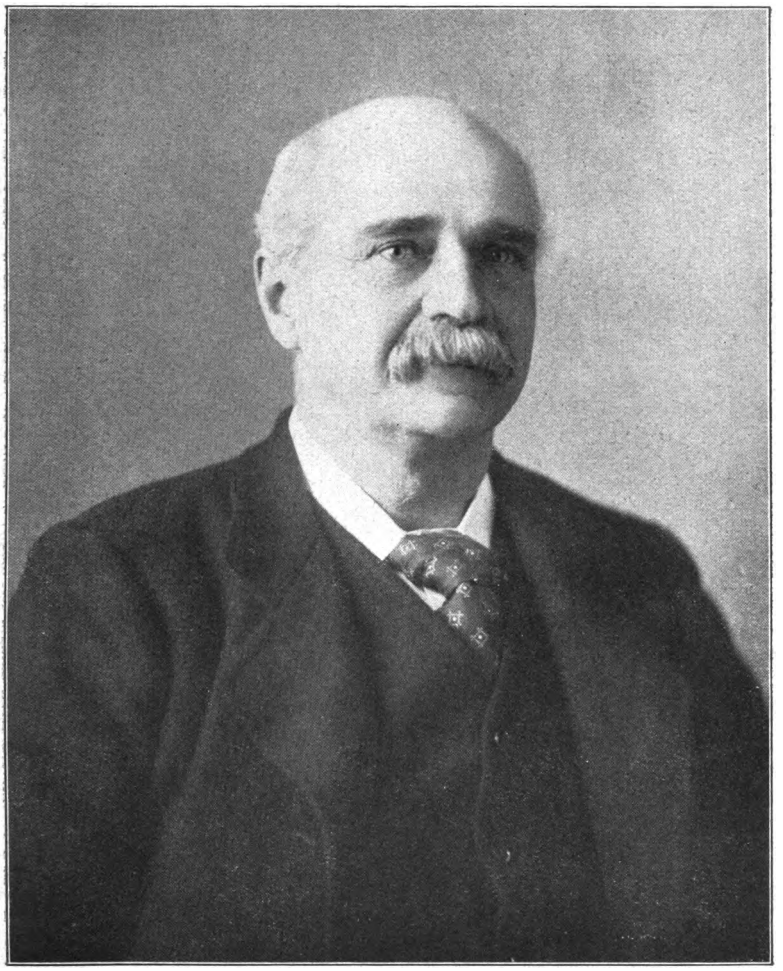

Capt. Sir William de W. Abney. K.C.B., F.R.S.

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formed classes of officers and men for studying this subject and the first edition of his book *Instruction in Photography*, destined afterwards to reach its eleventh edition and to be the guide of innumerable students of the art, was printed at the S.M.E. in 1871 as a small pamphlet for the use of his classes. Under his energetic direction the importance of photography became apparent and it was found impracticable to retain this subject under the tutelage of the Instructor in Electricity. A separate Chemical and Photographic School was accordingly formed in 1874 and Abney became Assistant Instructor in Chemistry and Photography, an office in which he had many successors, and which remained in being until recent years, when the twin schools were merged into the Survey School. In 1877 he left Chatham, handing over his school to Capt. Leonard Darwin, and joined the Department of Science and Art at South Kensington then under the direction of that able administrator, the late Sir John Donnelly, R.E. There he at once established a laboratory, placed in one of those hideous iron buildings known to two generations of Londoners as the "Brompton Boilers" and for nearly thirty years that laboratory was the source and fount of an unending stream of original experiment and research.

From 1874 onward Abney was so intimately connected with the advance of photography as an exact science that to give a narrative of his work would be in effect to write a history of that science. Those curious may read this history in the *Encyclopædia Britannica*, Article "Photography," but they must bear in mind that this article was written by Abney himself and cannot be taken as a completely adequate account of his own contributions. In 1874 the only extensively used photographic process was the collodion "wet-plate." The gelatine dry-plate, though actually first made in 1871, was then in its infancy, and the various dried collodion plates and collodion emulsions, in which Abney was one of the foremost experimenters, were only used by a few eager inquirers. In 1878 and 1879, due mainly to advances made by Bennett and Abney in this country and van Monkhoven on the continent, a rapid gelatine emulsion for all practical purposes identical with that used to-day was first produced and the modern "instantaneous" photography made possible. All the later advances; the improvement of the sensitiveness of the plate both to white light and to colours; the preparation of half-tone and process blocks for printing; the development of three-colour work; the measurement of the sensitiveness of plates and the use of photography for accurate photometry, found Abney either as discoverer or, where not the actual inventor, an early and acute investigator and critic. His communications to scientific societies and journals numbered considerably over one hundred. A mention of a few of the most important of these will indicate the variety and high character of his work. Thus we note one in 1874

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on Dry Plate Processes for Solar Photography, describing the most efficient methods of preparing and using collodion dry plates; this was in connection with the Transit of Venus in that year, for which Abney was given complete charge of the arrangements for photographic observations; in 1877 one on the action of Alkaline Developers, showing for the first time the chemical reactions which took place when such developers were applied. This had been one of the great advances made in collodion dry-plate photography though their use up to that time was entirely empirical and the users did not bother about the chemistry so long as they got the results. Such an attitude was entirely repugnant to Abney's scientific spirit and to him it would have been unthinkable to employ any process without making every endeavour to understand it completely, and thus, by this understanding, render further advance possible. In 1880 the Royal Society published his great paper "On the Photographic Method of Mapping the Least Refrangible End of the Solar Spectrum," wherein he described his investigations, begun while he was at Chatham in 1875, on the preparation of a plate sensitive to rays far beyond the visible region of the spectrum. A further and more complete memoir on the same subject appeared in 1886. This was one of the most remarkable researches made by him. He succeeded in obtaining an emulsion of bromide of silver in collodion which was sensitive not only to the red and infra-red rays but was impressed even by heat rays given out by bodies far below the incandescent point. He is said to have photographed a boiling kettle in a completely dark room. With this emulsion the use of the ordinary photographers' "dark room" with its red light was impossible and such manipulations as could not be done in absolute darkness were carried out under the illumination of a very feeble green light.

In another paper he recorded the application of these hypersensitive plates to the study of the absorption of the infra-red rays by organic bodies leading to important indications of their molecular grouping. In this part of the work he was assisted by the late Col. Festing, R.E. In 1882 the Council of the Royal Society awarded him the Rumford Medal in recognition of the value of this advance and his other contributions to scientific photography.

Other notable papers were on the transmission of sunlight through the earth's atmosphere, founded largely upon an extensive series of observations carried out at the Riffel Alp where the stone pillar used for supporting his instrument is still preserved as a historical monument; several on the effect ot different regions of the spectrum upon silver salts; upon the precise measurement of the sensitiveness of photographic plates, and upon colour vision. He was also the author of three standard books upon photography, each of which went through many editions, *Instructions in Photo-*

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graphy, Photography with Emulsions, and *A Treatise on Photography*, and several books on the theory of colour and colour vision.

The scientific side of his photographic work was not the only one that interested him or in which he excelled; he was himself an artist in water colours of considerable proficiency and most untiring industry, and devoted much attention to the artistic aspect of the science and to the production of views, both in England and in the Alps, exhibiting in a high degree the picture-making capacity of the camera.

He was elected a Fellow of the Royal Society in 1876 and served, at different times, in the office of President to the Royal Astronomical, the Royal Photographic, and the Physical Societies; also as Chairman of the Royal Society of Arts. He was President of Section A (Physics) at the British Association in 1889, when he gave an address summarising in a masterly style all that was then known of the theory of photographic action. He was a keen traveller, and was filled from youth with a love of the high mountains which never deserted him; for many consecutive years he spent his summer holidays in Switzerland or in the Italian Alps. In 1874 he was in Egypt superintending the observations of the Transit of Venus as visible at Thebes and brought home a most extensive and valuable series of photographs of the tombs and temples, then known to comparatively few people. In 1882 he planned another visit to Egypt to observe the total solar eclipse in May that year but at the last moment was prevented by temporary ill-health from making the journey.

He was created K.C.B. in 1904, a compliment, as he was fond of explaining to his friends, paid to his scientific work, not to his official career, and held honorary degrees from several universities. His activities were so many-sided and so various that it is impossible to do justice to them in the space here allowable and his friends will doubtless find many omissions. He was a most lovable character and a stimulating companion and no one who had the privilege of his friendship can ever forget it. He married twice and is survived by Lady Abney, a son and two daughters of the first, and one daughter of the second marriage.

E.H.G-H.

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CORRESPONDENCE.

AN EXPLORATION IN SOUTH-EAST TIBET.

To the Editor, R.E. JOURNAL.

DEAR SIR,—I observe in the number of R.E. JOURNAL for January, 1921, an interesting article by Major H. T. Morshead, D.S.O., R.E., describing his personal experiences of an exploration in South-East Tibet.

In his brief historical retrospect on page 22, he drops into an inaccuracy which has unhappily deprived a brother officer of the credit due to him. I allude to the phrase in the penultimate paragraph of the page, "the military and political expedition to Lhasa under Colonel Younghusband in 1904–5."

Colonel Younghusband was the head of the political mission that accompanied the military expedition to Lhasa under the command of Brigadier-General J. R. L. Macdonald, now Maj.-General Sir J. R. L. Macdonald, K.C.I.E., C.B., late Royal Engineers.

I feel sure Major Morshead is not desirous of suppressing the distinguished service of a brother officer of a former generation.

Yours very truly,

J. A. FERRIER, *Maj.-General (late R.E.)*.

NOTICES OF MAGAZINES.

MILITÄR WOCHENBLATT.

NO. 17.—*The Military-Political Situation.*—French support of Poland is, as usual, attacked and so is General Niessel, in command of the French Mission in that country. The British attitude towards the Soviet Government is described as undecided, chiefly because of the sympathy with which so many of the so-called working classes regard it. Lloyd George is not acquitted of holding similar opinions. England is stated to have no desire to play at being the strong man in a military sense, and her many responsibilities are enumerated, but Germany is warned to expect no concessions from this direction, because, through the madness of November, 1918, she is too feeble to demand them. The *M.W.B.* is surprised to see that the Franco-Belgian agreement has attracted so little attention in England; it declares that the agreement is not really directed against Germany, but against England and Holland.

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French Propaganda in Sweden.—The correspondent of the *M.W.B.* in Sweden draws attention to the active steps being taken in that country by France to divert her sympathies from Germany. A Swedish mission has been invited to come and study the battlefields; several Swedish officers are being attached to various units and schools in the French Army; French Universities are offering to take Swedish students at specially reduced fees; and tourist parties, to show Swedish travellers the devastated areas, are being advertised. The *M.W.B.* finds that these efforts are not being altogether unsuccessful, since the French minister in Stockholm has recently been offered 300,000 kroner to be devoted to rebuilding the town hall in Craonne.

No. 18.—*Ludendorff.*—A book on Ludendorff is reviewed at greater length than it appears to merit. The author attributes all Germany's misfortunes to this man, who is declared to have been afflicted with among other weaknesses, the following—"Paucity of ideas, helplessness, lack of foresight, dishonesty, obstinacy, a liking for public-house politics, illusions, fear of the truth, and confusion of mind." His moral character is then attacked in a way that must surely come within the scope of any reasonable law of libel. The author's strategic ideas are not less striking; according to them Germany should have dealt a heavy blow on India, through Central Asia. It is curious that such nonsense can get a hearing in modern Germany.

The Reduction of the Austrian Army.—This seems to be meeting with even greater difficulties than in Germany, and to be causing greater hardships. Austria, with 6½ million inhabitants, of whom half a million are state employees of one kind or another, can only pay the very smallest pensions to her old soldiers and particularly to such a poorly represented class as the officers. When it comes to giving out appointments, the latter get no consideration, however suitable they may be. The Institute of Military Geography, which used to print the world-famous Austrian Staff maps, is now devoted to the publication of election posters.

No. 19.—*Military Notes from South Eastern Europe.*—The "Little Entente" is taking an active line in its foreign policy and seems to lean more towards the East than the West. The adhesion of Greece, Bulgaria, and even German-Austria is discussed. Jugo-Slavia is the strongest member of the entente from the military point of view and a good harvest has placed the country on a fairly sound basis economically. Tchecho-Slovakia is organizing an army with a peace strength of 180,000 men, rising on mobilization to 1,200,000; Olmütz is to be fortified on modern lines. French influence is said to be very strong; in October there were 164 French officers attached and a further 170 were expected. Seven out of twelve divisional commanders are stated to be French. The army is to be lifted out of politics. The Tcheck legionaries from Russia are found difficult to deal with. Roumania is stated to be reducing her armaments, but she is the only country, except Russia, wherein a conscripted army of labour is in being. The intention is to allow a man to serve his time in either the fighting or the labour army. Bulgaria is seeking permission from the entente to raise a small conscript army instead of the voluntary one of 33,000 prescribed by the treaty.

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The Hungarian National Army.—Good progress made in settling the country is reflected in the organization of the army, as limited by the peace treaty. There are seven areas, each raising one so called "Division," which really is no more than a strong mixed brigade. In spite of the disastrous effects of the revolution, the attack of Bolshevism and the invasion of the Roumanians, reconstruction is going on well.

No. 20.—*The Turning Point of the War*, by Lt.-Col. Muller-Loebnitz, is examined. This book appears to be one of the best which have appeared so far dealing with the Marne (1914). The general conclusion reached is that what was really a victory was changed by G.H.Q. first into a retreat and then into a defeat. The position of G.H.Q. is blamed in the first place and the personality of von Moltke in the second. The latter is compared, much to his disadvantage, with his predecessor von Schlieffen, whose plan it always was to ensure co-ordinated action by general directions rather than to interfere with initiative by formal orders. Even the latter were lacking in the case of the 1st Army from the 5th to 8th September, and the author thinks that von Kluck should himself have sent a representative to G.H.Q. failing any other method of establishing *liaison*. The dilution of the great Schlieffen turning project is emphasized by the fact that three-fifths of the German forces were held up in the German left flank, by inferior forces, while only two-fifths were allotted to the all-important right flank where they were opposed by superior numbers, and even these two-fifths were not up to the strength laid down for them. With von Schlieffen this would not have happened.

No. 21.—*The Military and Political Situation in England.*—Lieut.-General Balck says that England's foreign policy is entirely dependent on her domestic circumstances. The working classes, and in particular the "Triple Alliance," have distinct leanings towards Russia, which have influenced the government's dealings with Kameneff (*alias* Rosenfeld). If a Labour government was formed in England the writer does not think that Germany would be any better treated than hitherto, but the effects on the British Empire would be very serious. Self-governing dominions are said to be demanding more voice in Imperial politics and it is attributed to this that England has made no protest against the Franco-Belgian agreement and the projected fortification of Ostend. The Irish problem is discussed, but no solution suggested, though Lloyd George's refusal to entertain the idea of an independent Ireland is approved. British policy in Palestine, Syria, and Mesopotamia is stated to have as its main objective the formation of a pan-Arabian state, under British influence, which with a subservient Persia would give an overland route to India. Some not unfriendly moves towards Germany are noted, such as the manifesto of the Oxford professors, and questions in Parliament regarding the black troops used by the French in the occupied territory. These are, however, attributed to the increasing pressure of American commercial competition and not to any really friendly motives. The slow progress made in forming the regular and territorial armies is noted.

No. 22.—*The Military and Political Situation.*—The establishment laid down for the French Army in the coming year, 738,500 all ranks, is

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compared with the pious hopes of President Wilson and the League of Nations and many bitter comments made on it. Some satisfaction is found in the difficulty France is expected to meet with in filling it. The decision on the part of England to pay German individuals for their English investments is noted, but the writer is in a pessimistic mood and refuses to see any hope in any direction. Polish action in Lithuania is said to be viewed with satisfaction by the French, and it is thought that the Poles will not be easy to shift. D'Annunzio's example already has followers, in spite of the league. The publication in France of Lord Haig's volume of dispatches is noted. The writer thinks that the praises which the French have made this the occasion for giving both to Lord Haig and his men are rather uncalled for, but he likes the principle of praising generals and soldiers, and grudgingly admits that though the French may do it in a way not altogether in accordance with sober German taste, yet it is better than not doing it at all, or than flinging abuse at them, as is done in the Reichstag.

L. CHENEVIX-TRENCH, *Major, R.E.*

31. 12. 20.

REVUE MILITAIRE SUISSE.

No. 9.—*September*, 1920.

The Greek Campaign in Anatolia.—The original article is contributed by Colonel Feyler ; a sketch map is provided to illustrate the phases of the campaign dealt with in the text. This campaign was undertaken by Greece as the mandatory of the Entente Powers, and, it is said, more particularly of Great Britain, whose people, it is suggested, were disturbed by the activities of the nationalist party in Turkey. The mission entrusted to the Greek Army was the seizure of the railway connecting Smyrna with Panderma, and the occupation of the southern shores of the Black Sea, the main object being to ensure the safety of the Dardanelles Channel. Colonel Feyler deals with both phases of the operations against Mustapha Kemal Pasha undertaken by the troops under General Paraskevopoulo. The first phase, which consisted in the offensive directed towards the east, began on June 22, 1919, and resulted in the capture of Ala-chehr within three days. For the protection of the Greek right flank, a detachment operated along the Meandre R., whilst the left flank was covered by operations directed against Ak-hissar. Ala-cheher having fallen on the 25th *idem*, the victorious Greek troops were at once pushed eastward to a distance of 50 k.m. beyond this place. At the same time the troops on the left flank advanced from Ak-hissar to a point somewhat to the north of Soma. The second phase consisted in the operations for the capture of Panderma. The forward movement northwards began on the 29th *idem*. In connection with this advance, a weak column was landed in the Gulf of Adramit and marched from Kemer, *via* Adramit and Agrinia on Bali-Kesser. Bali-Kesser was occupied by the Greeks on the 30th *idem*, 1,200 prisoners and 54 guns falling into their hands. On July 2, whilst the main body resumed its march northwards, a newly formed column

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was landed at Panderma, under the cover of the guns of the fleet, and moved southwards, joining hands with the advanced guards of the main body some 25 k.m. N. of Bali-Kesser. On July 8, the coast from Panderma to Moudania was in the hands of Greek and British troops, the latter having been landed at Moudania on that date.

No. 10.—*October*, 1920.

Gas Warfare.—Premier-Lieutenant Matthey, the author of the original article, recalls the wonderful way in which the French troops recovered from the "surprise" effect produced by the first German gas attack on April 22, 1915, and the success with which their subsequent preventive measures in relation to gas warfare met. He points out that the term "gas" is misapplied in the use which is made of it in relation to the diabolical methods of chemical warfare introduced by Germany; of the 19 poisonous substances used by the Germans 15 were liquid, 2 solid, and 2 alone gaseous. Owing to the character of Germany's chemical industry, she was in a position early in the war to obtain rapidly enormous quantities of "warfare gas" (*gaz de combat*), the total production of which is stated to have been 48,000 tons.

In the original article a list is given, in the order in which their use was introduced in the war, of the "gases" employed by the Germans from April, 1915, to September, 1918, the toxic properties of each gas being stated. A brief description is given of the methods of gas-attack employed by the Germans and the measures taken by them at different periods to obtain the advantage of surprise effect. A short account is given of the steps by which the gas helmet was by degrees improved in France, until the type known as the *Masque A.R.S.* was finally introduced in 1918. The number of gas helmets of various types manufactured in France during the war totalled 47,600,000. The original article is based on the work entitled *La guerre des gaz* by Drs. Voirel and Martin and articles on the subject by M.M. Cornubert and Florentin which appeared in numbers of the *Revue générale des sciences pures et appliquées* for January and April, 1920.

Notes and News.—Switzerland.—The demobilization of the Swiss Army was completed in August last. Economy is the order of the day, the reduction of the military budget has resulted in the annual contingent of recruits for the Swiss Army being fixed at 18,000 instead of 27,000 men. Among the other measures adopted is the conversion of fortress machine-gun companies into infantry machine-gun companies: the object of the last-named measure is political, that is to say, in order to show that the *garrisons of the fortresses have been reduced.*

France.—A special correspondent contributes some very interesting notes on the French Army. He examines the military situation in France in the autumn of 1914; starting with a "standing" army of 33,000 officers, 856,000 men and 229,000 horses, the fighting forces of France were raised on mobilization by adding some 3 millions of troops. The creation of novel units, owing to the technical developments in warfare, brought about a somewhat remarkable change in the main characteristics of the French Army. The old army reached its maximum development by May 1, 1915, whilst the reorganization owing to the

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technical progress was complete by October 1, 1918. A comparison is made of the percentages of combatants to non-combatants in the French Army on the two dates mentioned, the figures being as follows :—

	May 1, 1915		*October* 1, 1918.
Combatants ...	... 86·1 %	—	74·0 %
Non-combatants ...	... 4·1 %	—	12·2 %
Services	... 9·8 %	—	13·8 %
	100·0		100·0

The number of battalions in 1918 was 31 less than in 1914, in spite of the fact that 200,000 more men were serving with the colours : the number of cavalry squadrons, which was 510 in 1914, stood at 431 on November 11, 1918—of the latter 90 were employed dismounted ; the number of batteries of artillery which stood at 1,508 on mobilization in August, 1914, had increased to 2,975 by the date of the armistice ; the number of engineer units increased by 150 during the war—the allotment of *Sapeurs-Mineurs* to the divisions and Army Corps was doubled, a considerable increase took place in the number of telegraph units, novel units were formed, of which the best known are the Schilt companies (flame-throwers) and Z companies (gas warfare) ; the aviation service which consisted in 1914 of 23 squadrons and 4 balloon companies had at the end of the war reached to a total of 261 squadrons of various kinds and 76 balloon companies ; the " tank corps " (*artillerie d'assault*) first raised in 1917 consisted of 2,500 " light tanks," and about a hundred " heavy tanks " ; the motor transport with the French Army, which consisted in August, 1914, of 9,500 vehicles (all requisitioned) amounted on November 11, 1918, to 88,400 vehicles and 9,700 tractors. On August 2, 1914, the number of troops mobilized in France was 3,800,000 ; in July, 1915, the numbers of men serving stood at 4,978,000 ; whilst at the date of the Armistice the French Army mustered 4,150,000 all ranks. On August 1, 1914, the French Corps of Officers stood at 34,225, by the beginning of 1920 the number of officers had increased to 47,133. Other interesting data are also furnished.

Portugal.—A special correspondent writes that a committee consisting of officers of all branches of the service has been appointed by the War Minister to review the vast amount of legislation affecting the Portuguese Army passed during the war with a view to a simplification of the law relating to military service. It is proposed by the Minister to retain the army organization introduced in 1911, but there exists a strong feeling in military circles that a new organization is required based on the experience of the Great War.

France.—The *Revue d'Infanterie* has made its reappearance ; it was not published during the war.

W. A. J. O'MEARA.

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CURIOSA MATHEMATICA, No. 2.

DEAR SIR,

With reference to the above, my problem (printed in *R.E. Journal*, January, 1892) was to use only *three* fours; and I got as many as 80 numbers out of the first hundred, the missing ones being 41, 51, 57, 67, 69, 71, 73, 74, 75, 76, 77, 79, 82, 83, 85, 86, 87, 89 91, 93.

The only extra one I ever got was in 1903 from Lieut. (now Lt.-Col.) C. Hogg, who worked out the question independently, and got exactly the same 80 numbers as I did, with the addition of 75. This was through using the sign for *per cent.*, which seems quite legitimate, though it had not occurred to me.

$$75 = \frac{\sqrt{4}}{4\,{}_{0}/^{0}\,\sqrt{.4}}$$

Of course the first missing number, 41, can be got in numerous ways with *four* fours, some of which are rather interesting, *e.g.*,

$$41 = \sqrt{\frac{\lfloor 4 + 4 + \lfloor 4}{\lfloor 4}}$$

$$41 = \sqrt[\infty]{4}\,{}_{0}/^{0}\,(\sqrt{}\sqrt{}\,4^{\lfloor 4} + 4) = 1\,{}_{0}/^{0}\,(4096 + 4).$$

But I soon decided that if I published it again, I would limit it to *two* fours, and the problem would then stand as follows:—"What numbers can be found up to 100, using the digit 4 twice in each case? Neither any other digit, nor 0, may be used; but all *signs* expressing a mathematical operation are allowed." And my answer would be, the following 26 numbers, 1, 2, 3, 4, 5, 6, 8, 9, 10, 12, 16, 20, 22, 23, 24, 25, 26, 28, 32, 36, 44, 48, 54, 60, 64, 96. The only ones that present any difficulty, and are therefore of any interest, are

$$23 = \lfloor 4 - \sqrt[\infty]{4} \qquad 36 = \frac{\lfloor 4}{\sqrt{.4}}$$

$$32 = \sqrt[.4]{4} \qquad 64 = \sqrt{}\sqrt{}\sqrt{}\,4^{\lfloor 4}$$

The infinitieth root has often been objected to, but it seems to me to come within the definition of a "sign expressing a mathematical operation." And a mathematical professor at Cambridge once objected to my using 44, saying I was bringing in a 10, as it was merely a short way of writing $4 \times 10 + 4$, and could not be used with Roman numerals IV . IV. But the same might be said of repeating decimals, and it seems permissible to assume that we are dealing with ordinary figures. I feel doubtful about *log*, but I think it ought to be *disallowed* (if necessary by saying so in the question), otherwise *antilog* must be admitted too, and

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the problem would lose its comparative simplicity, as quantities of numbers could then be got with *two* fours, and many with only *one*, provided we set to work in a sufficiently roundabout way, *e.g.*,

$$15 = \log \sqrt{\ } \sqrt{\ } \sqrt{\ } \text{ antilog } \lfloor \log \sqrt{\ } \text{ antilog } (\text{antilog } \sqrt[\alpha]{4}).$$

With regard to the sign for the *summation* of a series, I thought it was necessary to show clearly what the series was, and this would require at least *three* fours, *e.g.*,

$$\Sigma \sqrt{4} + 4 + \ldots\ldots + \lfloor 4 = 156.$$

But if, as your correspondent suggested, $\Sigma 4$ may be used for $1+2+3+4=10$, I think the sign ought also to be disallowed, since the following numbers, and perhaps others, could be got with only *one* four, 3, 6, 10, 21, 55, *e.g.*,

$$6 = \Sigma\ (\Sigma \sqrt{4}).$$

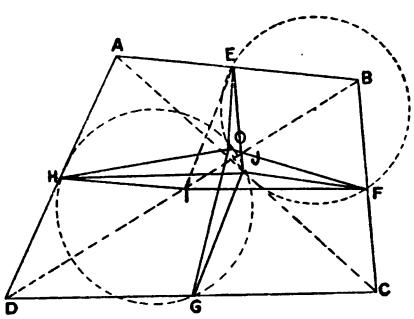
Yours, etc.,

W. H. TURTON, *Lt.-Col., late R.E.*

PROBLEMS.

PROBLEM 19 (Solution).

To prove that the 9 point circles of the triangles formed from any 4 points by taking them 3 at a time meet in a point.



EFGHJI are the centres of the sides and diagonals, then the circum-circles of $\triangle$s JEF, JHG, IHE, IGF are the 9 point circles in question.

Let the circles JEF, JHG intersect in O. Then if the circle GIF passes through O, then must

$$\hat{GOF} = \hat{GIF} = C.$$

Now since GIFC is a ||m

$$\hat{HOE} = \hat{JEF} + \hat{OEJ} + \hat{GHJ} + \hat{OHJ}.$$

This can be easily proved by drawing through O a line parallel to AC.

Hence

$$\hat{HOE} = \hat{JOF} + \hat{OEJ} + \hat{GOJ} + \hat{OHJ} = \hat{GOF} + \hat{OEJ} + \hat{OHJ}.$$

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But $\hat{HOE} = \hat{HJE} + \hat{OEJ} + \hat{OHJ}$.

Consequently $\hat{HJE} = \hat{GOF}$.

But $\hat{HJE} = C$, since HJ and EJ are || to DC and BC.

Hence $\hat{GOF} = \hat{C}, = GIF$.

and similarly $\hat{HOE} = \hat{HIE} = \hat{A}$.

Hence the four 9 point circles pass through O.

Q.E.D.

This problem has appeared in recent London University Honours papers.

PROBLEM 23 (A. F. S. Hills, Esq.)

In the following long division sum all the figures, except those shown, have been replaced by crosses. The division is complete, *i.e.*, the divisor goes into the dividend without remainder. Show that there are four solutions.

```
× × ×)× × × × × × ×4(×4× ×
      × × ×
      -----
      × × 4 ×
      × × × ×
      -------
        × × × ×
          × 4 ×
          -----
          × × × 4
          × × × 4
          =======
```

PROBLEM 24.

A man has 121 francs and 70 half-crowns. Reckoning 25 francs to be the equivalent of £1, find the number of ways in which the man can pay away one-third of the money in his possession, what is the smallest number of coins with which he can make the payment?

SOLUTIONS.

Correct solutions have been received from the following officers :— Problem No. 9 from Capt. A. C. Crooney, R.A. No. 11 from Lieut. E A. L. Gueterbuck. No. 22 from Major C. R. Satterthwaite, O.B.E.

J. M. WADE, *Lt.-Col.*

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THE WORK OF THE ROYAL ENGINEERS IN THE EUROPEAN WAR, 1914—1919.

CHEMICAL WARFARE.

1. Introduction.

The special *personnel* employed on this work during the late War was formed into Royal Engineer units under the supreme direction of a regular Royal Engineer officer, and an account of the activities of these units therefore properly belongs to the history of the Royal Engineers in the War. In the following notes only a brief outline will be given of the general organization, both offensive and defensive, and of the work done. No attempt will be made to describe chemical developments or technical details.

Chemical warfare in the shape of the discharge of clouds of poisonous gas was instituted without warning by the Germans early in 1915. After full consideration it was decided to undertake a similar offensive in retaliation, and Major C. H. Foulkes, D.S.O., R.E., commanding the 11th Field Company, R.E. (later Brigadier-General C. H. Foulkes, C.M.G., D.S.O.), was summoned to General Headquarters to organize the necessary measures. He at once prepared a report giving an outline of suggested tactics, etc.—a remarkable document almost completely borne out in after years. He then went to England to examine existing resources.

2. First Period.

Owing to the backward state of the chemical industry in the United Kingdom before the War chlorine was the only gas available for offensive purposes. Although easy to extemporise protection against, chlorine was by no means ineffective as a battle gas.

The output in June, 1915, was, however, very limited, and the existing plant had to be expanded and suitable receptacles, discharge pipes, etc., designed and manufactured. In addition suitable gas *personnel* had to be enlisted, organized into units, and trained. Four Special Companies were at first authorized, and civilian chemists were specially enlisted as Corporals, R.E. A similar number of suitable men were drawn from infantry battalions in the line, thus supplying the necessary practical trench experience.

Officers were obtained :—

(*a*).—By transfer in France of infantry officers with knowledge of chemistry, and—

(*b*).—By specially qualified civilians given commissions in England.

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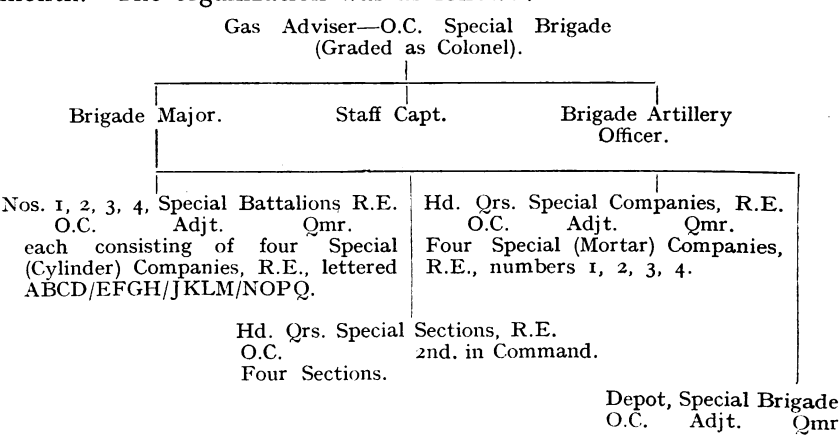
Men came out slowly from England, but one Special Company, R.E. (No. 186) was formed in July, and the other three (Nos. 187, 188, 189) were in being at the opening of the Battle of Loos.

All four Companies were formed and trained at a special depôt at Helfaut under Major Foulkes, whose title at this time was Gas Adviser, and who had direct access to the C.G.S., with whom he chiefly dealt.

Loos—September 25th, 1915.—Only seven weeks were available for training, and the work of organization was not complete before the Battle of Loos, and 12 officers from infantry battalions resting behind the line had to be borrowed to assist in the first gas attack at this battle. There had been no time to organize the systematic collection of information, and in consequence the impression was general throughout the Army that the results of this first gas attack had been comparatively ineffective. That this was by no means the case was acknowledged in the German official communiqué, and was later proved by a quantity of documentary and other evidence. Altogether, considering all the circumstances, it was no mean performance on the part of the Trench Warfare Department that gas was discharged at all on such a large scale only three and a half months after the first decision had been taken by G.H.Q.

Developments during Winter, 1915-16.—Subsequently to the Battle of Loos the method of releasing the gas was considerably improved by the introduction of rubber piping, and a number of smaller attacks were carried out during the Autumn and Winter of 1915, and early months of 1916. During this period phosgene was adopted as the main battle gas; the 4in. Stokes mortar was taken into use, and an apparatus was developed which showed a marked improvement as regards range over the "Flammenwerfer" first employed by the enemy at Hooge on July 30th, 1915.

An expanded organization for a "Special Brigade R.E.," put forward early in October, 1915, was approved by the War Office on the 17th January, 1916, and formation began during the same month. The organization was as follows:—


Gas Adviser—O.C. Special Brigade
(Graded as Colonel).
Brigade Major.
Staff Capt.
Brigade Artillery Officer.
Nos. 1, 2, 3, 4, Special Battalions R.E.
O.C. Adjt. Qmr.
each consisting of four Special (Cylinder) Companies, R.E., lettered ABCD/EFGH/JKLM/NOPQ.
Hd. Qrs. Special Companies, R.E.
O.C. Adjt. Qmr.
Four Special (Mortar) Companies, R.E., numbers 1, 2, 3, 4.
Hd. Qrs. Special Sections, R.E.
O.C. 2nd. in Command.
Four Sections.
Depot, Special Brigade.
O.C. Adjt. Qmr.

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Special (Cylinder) Company, R.E. (lettered).—Armed with pistols and bandoliers—organized in a headquarters and six sections—total *personnel* eight officers, 250 other ranks.

Special (Mortar) Company, R.E. (numbered).—Each armed with with 48 4in. Stokes mortars—men equipped with rifle and bayonet—organized in a headquarters and four sections, each section divided into three sub-sections, each sub-section forming four mortar crews—total Company, 18 officers, 310 other ranks.

Special Sections, R.E. (for Flame Projector).—Each section consisted of three sub-sections each of which provided crews for two projectors (these sections were never fully equipped or up to strength). The Corporals of the first Special Companies were distributed throughout the Brigade as a nucleus, and the additional *personnel* was obtained for :—

Cylinder Companies—

(*a*).—Men with chemical qualifications transferred from infantry battalions in France.

(*b*).—Men with qualifications or of superior intelligence and good physique from England.

Mortar Companies—

(*a*).—40 young Artillery officers sent from England.

(*b*).—Men transferred from infantry or Trench Mortar Batteries in France.

(*c*).—Men from England.

Drafts from England arrived very slowly, and finally 1,000 R.A. drivers were obtained from the Base in France during June, 1916, which brought the Brigade up to something like strength. Most of the officers were obtained from units already in France, the chief qualification being practical experience in the front line. Temporary officers were transferred to R.E.; S.R. and T.F. were seconded. Practically none were allowed to be drawn from R.E. units. A great many commissions were given to the original chemist Corporals.

The Special Sections, R.E. were formed in England under Captain Livens, R.E. Special Reserve, both officers and men being principally drawn from the Royal Engineers. They arrived in France in July, 1916. The armament was intended to consist of 24 large and 48 portable flame projectors. The former required about 90 men loads each; while the latter weighed 160lbs. and were very bulky and awkward to carry. Very little practical use was actually made of these, but the special sections carried out a series of experiments at Toutencourt throughout the Summer and Autumn of 1916, and the well known Livens projector was first tried there.

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3. SECOND PERIOD.

The first Battle of the Somme provided the second distinct phase in the evolution of chemical warfare. This was a period of cloud discharges, mainly of white star gas, of which no fewer than 110 took place. By this time a high standard of efficiency had been attained, and subsequently to July 1st, practically all the discharges were carried out at night, a procedure which, while adding to the technical difficulties of the attacks, greatly increased their effect on the enemy. The large flame-projectors were fired ten times (two came into action just before zero on July 1st), and the semi-portable type four times.

In September the earliest gas projector discharges took place opposite Thiepval and Beaumont Hamel, ordinary oil cans being used as mortars, and others of smaller diameters as bombs.

In October a very successful cloud attack was carried out on the French front at Nieuport.

4. THIRD PERIOD.

Considerable developments took place in the year 1917. During the Winter, 1916-17 there was no general withdrawal of the Special Companies from the line, but the projector was developed and greatly improved—large numbers were manufactured, and the Brigade was trained in its use.

In February, 1917, a reduction of about 15 per cent. of the strength of the special Brigade was effected in order to provide *personnel* for gas defence in various formations.

The first projector operation on a grand scale was carried out on April 4th at the opening of the Battle of Arras when 2,268 drums were fired. Many discharges took place subsequently during 1917, as well as a few cloud attacks, and assistance was also rendered to the Belgian Army by attachments of the Special Brigade.

By April, 1917, sufficient supplies of bombs filled with lethal and lachrymatory gas, as well as with smoke and thermit, had been received in France, and all the mortars of the Brigade were continuously engaged in carrying out gas bombardments or in co-operating in Infantry raids with smoke and thermit. Drums filled with oil, thermit, phosphorus, and "stinks" were fired at times from the Livens projector, in addition to its normal projectile—the gas drum.

Oil drums primarily designed for incendiary purposes were frequently used when projectors had been installed, but when conditions made the use of gas uncertain or undesirable, and later drums filled with thermit were fired on several occasions. Drums filled locally with red phosphorus were designed to form smoke screens at points beyond the range of the 4in. Stokes mortar; and use was made of various chemicals which produced an unpleasant but innocuous smell. Bombs filled with such "stinks" were frequently used in

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raids, and led the enemy to put on masks unnecessarily in the belief that they were being gassed.

Revised Organization.—During this year the organization was changed. The four battalion headquarters and the headquarters, Special Companies, each becoming Headquarters, Special Companies, R.E. First-Fifth Armies. Cylinder Companies retained their lettering, and used cylinders or Livens projectors according to circumstances. Mortar Companies retained their numbers and their Stokes mortars, but gradually were instructed in the use of projectors. Special Sections, R.E. became 'Z' Special Company R.E. (Projectors), and were also later instructed in the use of cylinders. Companies were allotted to Armies as required by the tactical situation.

In July, 1917, a new departure was made by the production of a gas warfare monthly summary of information, which was issued by the General Staff and widely distributed up to the end of the War.

5. Fourth Period.

In December, 1917, the Special Companies after many months of continuous activity were withdrawn into G.H.Q. Reserve for rest and training, and the opportunity was taken to develop a new method of cylinder discharge from retired positions. Great efforts were also made to overcome the main difficulty that had been experienced in gas installation, namely, that presented by the shortage of labour; and the use of light trench tramways was developed, and the Leeming principle of aerial ropeway transport adopted.

At the end of January, 1918, the first two American Gas Companies were attached to the Special Brigade for instruction, and to complete their training they took part in several of the actual gas attacks on the British front.

Early in March operations were resumed against the enemy and many of the Companies were involved as infantry during the great German attacks. At one period preparations were complete for organizing them into an infantry brigade in case of need, but the scheme was not actually put into operation.

Ten retired cylinder operations on a large scale were carried out —in nine cases from railway trucks which were run up into position and withdrawn immediately after the discharge, and no fewer than 300 projector operations were completed. In fact, so well did the Companies adapt themselves to the new tactical conditions that, in spite of being 20 per cent. under strength, their activity in this period was actually greater than at any other time during the War, and infantry assistance could be largely dispensed with. With the development of the cloud method of attack, the provision of a satisfactory design of percussion fuze for gas bombs (the 147), the arrival of the Leeming ropeway, etc., offensive operations had reached their maximum of efficiency at the time the Armistice was signed.

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6. SUMMARY OF OPERATIONS.

Altogether during the War 768 gas operations (in addition to many smoke) were carried out as under :—

	Cylinders discharged.	Projector drums fired.	4-in. Stokes Mortar Bombs fired.	Flammenwerfer fired.
1st period	6,045	—	—	—
2nd. ,,	42,559	290	3,754 gas 15,936 smoke	12
3rd ,,	12,183	98,102	100,532 gas 14,800 smoke and thermit	2
4th ,,	27,181	95,476 gas 3,072 dummy oil and smoke	34,874 gas 7,512 smoke and thermit	—
Total ...	87,968	196,940	177,408	14

This represents a total of 5,700 tons gas discharged apart from smoke, oil, and thermit.

The magnitude of these operations varied from the electrical discharge of 5,110 cylinders (148 tons of gas) to the firing of a few score Stokes mortar bombs from the outskirts of a partially captured village. The largest simultaneous discharge of projector drums took place on 21st March, 1918, when 3,728 drums and 920 4in. Stokes mortar bombs were fired into Lens and its outskirts. On another occasion, March 19th, 1918, 2,959 drums were fired into St. Quentin. The largest discharge of oil drums took place on June 4th, 1917, when 1,500 drums were projected into the woods on the slopes of the Messines Ridge.

Nor do the operations tabulated above represent the whole of the work carried out by the Special Brigade; a great many other operations were prepared, but were not completed owing to the changes in the tactical situation, or for other reasons. For instance 286 tons of gas were ready for liberation in front and on the south flank of the Messines Ridge in June, 1917, but conditions were not favourable for discharge until after the successful advance, when the operation was abandoned. Very many smoke operations were also carried out which cannot be included in the table, both by 4in. Stokes Mortar Companies, and also by Cylinder Companies. In one such operation just north of Armentières on September 28th, 1918, 15,000 smoke candles were lighted by a single Special Company.

Surprise was always the essence of success in these operations, and this combined with variety was constantly sought after, even to the extent of "violating the laws of gas warfare," of which the enemy actually complained in a captured order! It is an interesting fact

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that the surprise tactics of carrying out short concentrated bombardments with lethal gas, which were adopted by all the Allied artilleries, and later still by the enemy, were first practised by the Mortar Companies.

In the intervals of their normal occupation the Special Companies were constantly employed on various engineer duties such as bridging, railway, road and trench construction, etc., etc. Table I. illustrates the total amount of gas discharged on each night during the War. *Photograph* I. shows flame projectors in action; *Photo*. II. shows Livens projectors being loaded, and *Photo*. III. bombs from Livens projectors bursting.

7. Casualties Inflicted on the Enemy.

Gas officers of the various formations worked in close touch with the intelligence branch of their respective staffs, and collected a large amount of information from time to time of the results of the various gas operations. Evidence was obtained from the following sources, which are arranged in order of value :—

(*a*).—Observations and deductions made by our own troops.
(*b*).—Statements of prisoners and deserters.
(*c*).—Letters and diaries found on the battlefield.
(*d*).—Enemy official documents.

The majority of the evidence that was collected related to the losses of small units forming only a portion of the enemy's troops known to have been affected, but casualties amounting to several hundred were frequently reported as the result of single operations. No information could be obtained regarding more than half of these attacks, and the only complete account ever received was volunteered by a deserter with reference to a cloud attack carried out on the French front at Nieuport on October 5th, 1916. On this occasion nearly 1,500 of the enemy were reported to have lost their lives, though this particular operation was not thought at the time to have been very successful owing to the installation having been discovered by a hostile raiding party some days previously. It was frequently reported, more especially in the later stages of the War, that German prisoners appeared to have received definite instructions from their officers to conceal their gas losses, and the existence of the necessity for re-assuring their troops was disclosed in a number of captured documents. For instance the following extract from a statement issued by "Gas Services, Sixth Army," dated 20. 1. 17, was captured in August, 1918 :—

* * * * * * * * * *

"Cylinder attack. In the evening (13. 11. 16) a cylinder attack in two waves took place between 6.45 and 8 p.m. from the

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English positions from Blairville to Ficheux on the boundary between the First and Sixth Armies. The very dense wave, principally chlorine, was carried by the northwest wind at a speed of 2-3 metres per second a long way over the country, so that men at a distance of 50 kilometres from the point of discharge smelt chlorine strongly, and were affected with coughing. There were no casualties."

* * * * * * * * * *

Another of our gas clouds had been previously reported by a German officer to have inflicted casualties at a distance of 36 kilometres, but the improbability of the statement in the above report that there were no casualties is obvious, especially as the effects of this particular operation had already been reported from two quite independent sources as follows:—

"Prisoner put the deaths at 20 per cent. of the Regiment due to the men having masks in which the screwing portion was old and defective."

"The Fusilier Regiment's 1st Company had approximately 40 casualties, of which 25 eventually proved fatal."

Both these regiments were in the front line.

It will be long before the influence of these operations on the course of the War can be justly estimated. From the available evidence it was considered by the Director of Gas Services that the enemy lost approximately one man from every cylinder discharged, from every five drums projected, and from every ten Stokes mortar bombs fired, and that the mortality amounted to at least 25 per cent. of the total casualties.

8. Accidental Losses from Gas.

Only on two occasions during the War did our own troops suffer any serious losses from our own gas.

The first was on September 25th, 1915—on this occasion the number of discharge pipes was insufficient, only two being available for each emplacement, so that they had to be connected to one cylinder after another during discharge, a procedure which resulted in a certain amount of leakage. Further escapes of gas were caused by the intense hostile artillery retaliation provoked; while in the northern part of the front of discharge the direction of the wind was unfavourable, and although cylinders were turned off a few seconds after they had been opened, some of the bays were flooded with gas.

The reports, current at the time, of the casualties, were fortunately much exaggerated; in actual fact the bulk of the cases were very mild, and only 10 proved fatal (including three of the gas *personnel*).

The second accident took place on September 1st, 1916, opposite

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Messines, when for some unexplained reason the cloud blew back over part of the front of discharge for a few minutes ; precautions to prevent crowding of the trenches had been taken, and only 19 of the casualties proved fatal.

The only other accidental casualties that occured were :—

(*a*).—From projector drums falling wide. Only three or four instances of this nature took place, and casualties were very few.

(*b*).—From cylinders being burst while awaiting discharge in the trenches. Careful records show that about thirty accidents of this kind were reported. In about half there were no casualties at all, while in the whole of the remainder 29 fatal cases of gas poisoning occurred, a very small number considering the extent of the front and the length of the period covered ; (as many as 20,000 cylinders have been in position in the trenches at one time).

The casualties among *personnel* of the Special Brigade amounted during the whole War to 5,384, but those due to gas poisoning were never high except on the two occasions mentioned above.

9. Defensive Organization and Training.

Immediately after the first German gas attack in April, 1915, defensive measures were organized from the office of the Director General of Medical Services.

During June and July, 1915, officers were appointed at the Headquarters of Armies to direct anti-gas defence and training, a school being established for this purpose in each Army. These officers, known at first as Chemical Officers, then Gas Officers, were finally given the title of Chemical Advisers.

In March, 1916, both the offensive and defensive branches of Gas Services were co-ordinated under the Director of Gas Services at G.H.Q., who at once obtained official recognition of the appointment of Gas Officers at Divisional Headquarters, appointments which had previously been unofficially filled by locally selected officers in the case of certain Divisions only.

Divisional Anti-gas Schools were placed on an established basis, and six trained gas N.C.O.s, many of whom were drawn from the Special Brigade, were included on the establishment of each Divisional Gas Officer. Of these N.C.O.s one was attached to each Infantry Brigade in order to check unit inspections and respirators, to supervise the general state of gas defence in the brigade, and to report on gas attacks or gas bombardments of any magnitude. Of the remaining three, one was attached for duty to the Divisional Artillery, and the other two acted as Instructors at the Divisional Anti-gas School.

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In March, 1917, the development of anti-gas work occasioned by the increased use of gas led to the appointment of a Corps Chemical Adviser to every Corps Headquarters.

In November, 1917, Divisional Anti-gas Schools were abolished and Corps Anti-gas Schools substituted, with the idea of increasing the centralization of training. This policy would have been still further extended during the Winter of 1918 if hostilities had not ceased, the intention being to form five Central Gas Schools to take the place of the Army and Corps Schools as Anti-gas Wings of the general Central Schools.

In all cases anti-gas training was carried out in accordance with a definitely laid down scheme which was defined in a pamphlet issued by the General Staff " Defence against Gas " (S.S. 534.).

The average number of respirators inspected monthly by members of the Gas Services as a check on unit inspections in Army areas during the latter months of the War was well over a quarter of a million. In many cases Divisional Commanders found it advisable to appoint unofficial Brigade Gas Officers, and this was done in about 75 per cent. of the infantry brigades in the line. In some cases also unofficial gas officers were appointed for Divisional Artillery, Corps Heavy Artillery, Corps Troops, etc.

Training at the Bases.—In January, 1916, a Chemical Adviser was appointed to Headquarters L. of C. to co-ordinate respirator issues, fitting, training, and inspections at bases. The work of training reinforcements and casuals was carried out at six Base Anti-gas Schools under the control of the Chemical Adviser L. of C.; during the year 1918 alone no less than 1,557,809 all ranks passed through these Base Schools.

Central Laboratory.—The Central Laboratory was first established in April, 1915, at St. Omer, and subsequently moved to Hesdin. In addition to miscellaneous work undertaken for various departments and not connected with the subject of gas, the laboratory carried out all analyses made in France of enemy gas shell filling, German respirator containers, contaminated earth, water and clothing, as well as periodical examinations of British respirators and containers withdrawn from general service.

The final organization of the whole of the gas services in France as existing at the end of the War is given in the Appendix.

10. Notes on Enemy Gas Services.

Although the enemy had a considerable start in chemical warfare it is certain that he very soon fell behind in both offensive and defensive methods and tactics. His defensive measures always appeared to be inferior to our own, though the thoroughness of collective protection varied greatly with formations. It is, however,

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not intended here to outline the history of the evolution of enemy gas warfare: two specific illustrations are given below, as being of interest.

The first known employment by the enemy of projectors similar to our own was on 10th-11th December, 1917, opposite Cambrai and Givenchy. Just before the great offensive of March, 1918, a demonstration was reported to have been given with new German projectors—these consisted of iron tubes specially made resembling open gas cylinders, and were built into the ground close together. As far as the informant knew no base plates were employed and on discharge the projectors sank about three feet into the earth. A thousand H.E. projector drums were reported to have been fired by the enemy at the opening of the offensive on the 21st March.

Photo. IV. shows an enemy projector installation that was captured at Boisleux-St. Marc on August 21st, 1918. 123 projectors were dug in, in three parallel rows, and were practically completed for firing at the moment of capture. *Plate* I. gives details of the ordinary German Flammenwerfer.

In June, 1918, a grenade was found by the French which was similar to the ordinary German stick grenade, was marked with a 'G' and labelled with instructions, of which the following is the translation:—"Gas hand grenade, time fuze—only to be thrown in the direction of the wind or in a current of air. Cloud formed on explosion."

In addition to the explosive effect the grenade produced a gas effect similar to that of blue cross shell.

Origin of Flammenwerfer.—The following translation of an extract from the *Hamburger Nachrichten* is interesting:—

* * * * * * * * *

"Our Flemmenwerfer troops owe their origin to a mere incident. Their present commander, Major R., when an officer of the Reserve, received the order, during peace manœuvres, to hold a certain fort at all costs. During the sham fight, having employed all means at his disposal, he finally alarmed the fire brigade unit, which was under his orders as commander of the fort, and directed the water jets on the attacking force. Afterwards, during the criticism of operations in the presence of the Kaiser, he claimed that he had subjected the attackers to streams of burning oil. The Kaiser thereupon enquired whether such a thing would be possible and he received an answer in the affirmative.

"Long series of experiments were necessary before Engineer L. succeeded in producing a combination of various oils, which mixture is projected as a flame on the enemy by means of our present-day Flammenwerfer.

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"Major R. occupied himself in peace time with fighting fire as commander of the Munich Fire Brigade. The 'Prince of Hades,' as he is called by his 'fire spouters,' enjoys great popularity among his men as well as among the troops to whose assistance he may be called.

He can look back on an important development of his units. Whereas in January, 1915, Flammenwerfer troops consisted of a group of 36 men, to-day they constitute a formation with special assault and bombing detachments, and are furnished with all requisities for independent action.

In reading Army communiqués, we often find mention of these troops. If difficulty is experienced in clearing up an English or French infantry nest, the 'Prince of Hades' appears with his hosts and smokes the enemy out.

That conditions of membership of this unit hardly constitute a life insurance policy is obvious; nor is every man suitable. Special men who are physically adapted and who have given proof of keenness in assault are necessary for such work."

* * * * * * * * *

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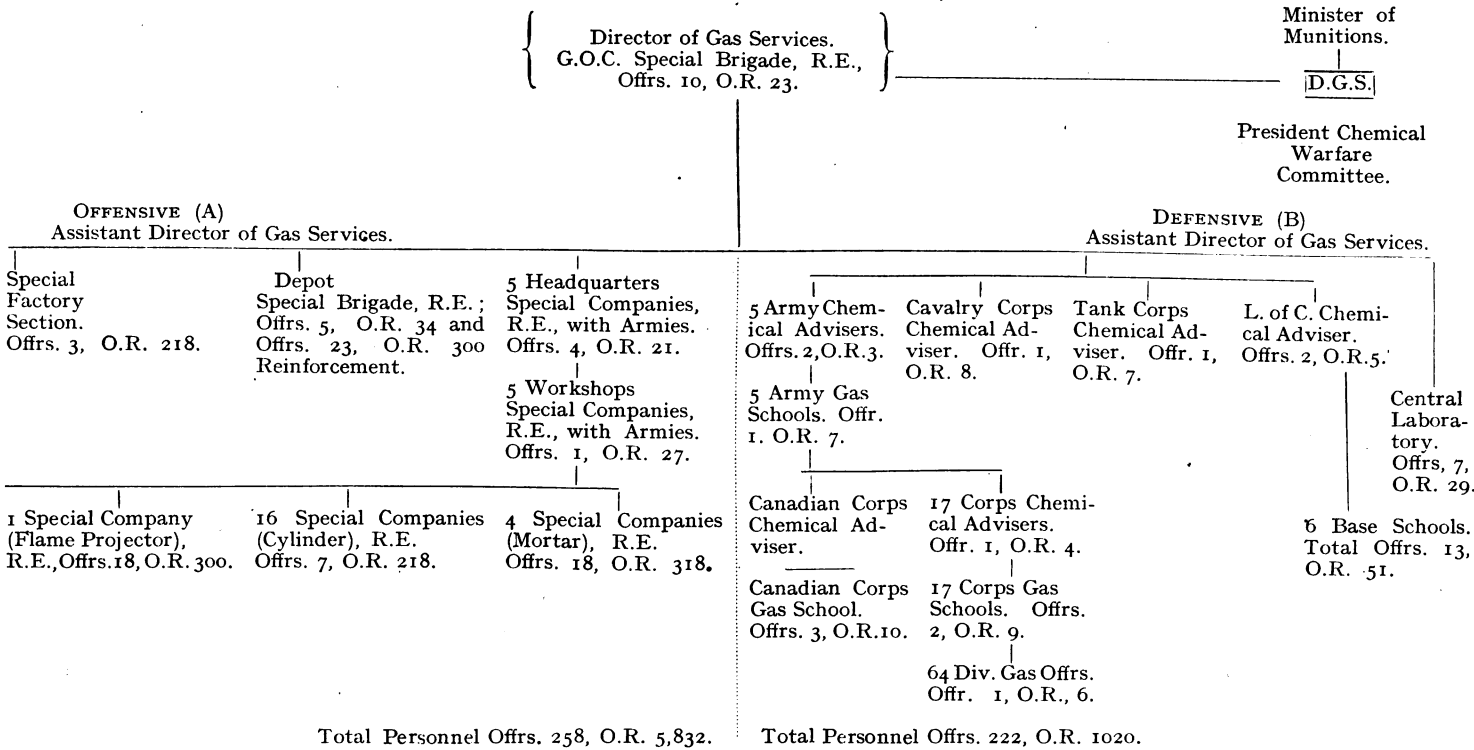
APPENDIX.

ORGANIZATION OF GAS SERVICES, B.E.F., FRANCE.



Total Personnel Offrs. 258, O.R. 5,832.

Total Personnel Offrs. 222, O.R. 1020.

GRAND TOTAL (including H.Q.), Offrs. 490, O.R. 6,875.

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TABLE I.*

Date.	Tons of Gas.	Cylinders.	Projector Drums.	4" S.M. Gas Bombs.	4" S.M. Smoke Bombs.	4" S.M. Thermit Bombs.	Operation.
1915.							
Sept. 25	68	2480	—	—	—	—	Battle of Loos.
27	9	325	—	—	—	—	
Oct. 12	35	1225	—	—	—	—	Hohenzollern Redoubt.
Dec. 20	7	245	—	—	—	—	
21	20	700	—	—	—	—	
22	6	225	—	—	—	—	
1916.							
Jan. 8	9	325	—	—	—	—	
19	10	375	—	—	—	—	
Feb. to May	Expansion from 4 Special Companies to 21 and formation of the Special Brigade.						
June 12	5¼	200	—	—	—	—	
24	4½	150	—	—	—	—	
25	45¼	1600	—	—	—	—	
26	53	1900	—	—	—	—	
27	145¼	5100	—	—	—	—	
28	75¼	2650	—	—	—	—	
29	14	460	—	—	—	—	
30	57	1400	—	—	4400	—	Battle of the Somme, July 1st.
July 2	1½	—	—	—	400	—	
5	30	1040	—	—	—	—	
6	3	—	—	—	780	—	
8	14	400	—	—	400	—	
9	4	—	—	—	800	—	
10	11	400	—	—	—	—	
12	3½	—	—	—	800	—	
13	57	2010	—	—	—	—	
15	15	510	—	—	—	—	
16	½	—	—	—	250	—	
17	16	575	—	—	—	—	
22	1	—	—	—	380	—	
30	1	—	—	—	370	—	
Aug. 3	1¼	—	—	—	400	—	
7	1	—	—	—	350	—	
12	½	—	—	—	200	—	
13	5	160	—	—	—	—	
14	½	—	—	—	200	—	
16	½	—	—	—	150	—	
17	½	—	—	—	200	—	
20	66	1875	—	—	—	—	
21	2½	—	—	—	600	—	
23	½	—	—	—	150	—	
24	1½	—	—	—	400	—	
27	¼	—	—	—	100	—	
28	½	—	—	—	200	—	
29	¾	—	—	—	300	—	
30	66	2375	—	—	—	—	
31	19	650	—	—	—	—	
Sept. 2	½	—	—	—	200	—	
4	39	1325	—	—	200	—	
5	39½	1725	—	—	—	—	
9	¼	—	—	—	100	—	
14	¼	—	—	—	100	—	
15	18	620	—	—	—	—	
16	¼	—	—	—	100	—	
24	2½	—	—	700	—	—	
26	½	—	—	—	200	—	
Oct. 5	141	4925	—	—	—	—	
6	4½	150	—	—	—	—	
8	96	3400	—	—	—	—	
12	7	220	—	—	200	—	
14	1	—	—	—	300	—	
17	2	—	—	300	200	—	
28	4½	—	—	1200	—	—	
Nov. 3	¼	—	—	—	100	—	
6	¼	—	—	100	—	—	
1916.							
Nov. 8	20	675	—	—	—	—	
11	6	225	—	—	—	—	
12	33½	975	—	—	—	1400	—
13	45	1575	—	—	—	—	
17	¼	—	—	—	—	200	—
21	¼	—	—	—	200	—	
25	28	975	—	—	—	—	
Dec. 4	12	425	—	—	—	—	
14	½	—	—	—	200	—	
20	½	—	—	—	—	200	—
23	15	580	—	—	—	—	
1917.							
Jan. 9	1	—	—	—	100	250	—
11	1¼	—	—	—	150	250	—
17	4½	—	—	—	300	900	—
21	3	—	—	—	100	700	—
26	1	—	—	—	100	300	—
Feb. 5	½	—	—	—	—	200	—
9	¾	—	—	—	—	300	—
11	¾	—	—	—	—	200	—
12	¾	—	—	—	—	250	—
27	1	—	—	—	300	100	—
28	40	1420	—	—	—	—	—
Mar. 5	1¼	—	—	—	250	250	—
15	1	—	—	—	100	300	—
16	1½	—	—	—	550	—	—
17	4½	140	—	—	—	—	—
19	14	460	—	—	—	—	—
April 4	37	—	2290	1220	—	—	
5	6½	—	170	1200	—	—	
8	9½	—	—	2400	—	200	
9	9¼	—	—	1800	—	600	Battle of Arras April 9th
10	6½	—	300	600	—	—	
11	1½	—	110	—	—	—	
12	¼	—	40	—	—	—	
13	1¼	—	110	—	—	—	
15	2	—	150	—	—	—	
16	½	—	50	—	—	—	
17	14½	460	—	—	—	—	
21	3	—	200	—	—	—	
22	2¾	—	180	—	—	—	
23	¾	—	—	—	—	300	
26	3	—	200	—	—	—	
27	20	220	320	2400	—	—	
28	25	350	780	600	300	—	
29	55½	1520	650	1000	—	—	
30	1½	—	100	—	—	—	
May 1	2	—	150	—	—	—	
2	2½	—	200	—	—	—	
3	1	—	—	—	—	300	
8	18	—	1000	1000	—	—	
9	1	—	50	—	—	50	
12	2	—	75	—	300	—	
14	1	—	—	—	—	300	
15	24	500	450	800	—	—	
16	1	—	—	300	—	—	
19	1	—	—	—	300	—	
20	¾	—	—	—	200	—	
22	5	—	225	—	600	—	
24	20	—	1300	—	200	—	
25	21	—	850	2400	—	200	
28	3	—	—	—	800	—	
29	24½	—	1450	800	—	150	
30	13	—	750	400	—	—	
31	22½	—	1450	400	—	—	
June 1	14	—	1050	200	—	100	
2	1¼	—	100	—	—	—	
3	5½	—	500	700	—	—	
4	23¼	—	1500	300	—	100	

* The numbers given in this table are approximate only. The information is given in a chart which it has been found impossible to reproduce, but which has been deposited in the R.E. Library at the Horse Guards, where it will be available for inspection on application to the Librarian.—ED., *R.E.J.*

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TABLE I.—*Continued.*

Date.	Tons of Gas.	Cylinders.	Projector Drums.	4" S.M. Gas Bombs.	4" S.M. Smoke Bombs.	4" S.M. Thermit Bombs.	Operation.
1917.							
June 5	¼	—	—	—	100	—	Attack at Messines, June 6th.
7	6	—	—	900	300	400	
8	15	—	950	—	400	—	
9	9¾	—	660	—	—	—	
10	4	—	200	—	200	—	
11	1	—	—	300	—	—	
13	1	—	—	—	200	100	
14	57½	1725	500	200	—	—	
15	¼	—	—	—	200	—	
19	9¾	—	660	—	—	—	
21	27	—	1500	1600	—	—	
22	2	—	—	500	—	—	
24	½	—	—	—	200	—	
26	12	—	850	—	—	—	
28	4½	—	100	400	300	—	
July 1	¾	—	—	—	—	300	
5	¾	—	—	—	—	300	
8	6	—	—	1700	—	—	
9	51	1000	1450	400	300	—	
10	24½	550	500	400	—	—	
11	½	—	—	—	—	200	
13	1¼	—	—	—	—	500	
15	51½	—	2700	3600	—	—	
16	27	—	1475	1110	400	—	
17	5½	—	150	1000	—	—	
18	4	—	200	—	—	200	
19	9½	—	250	1600	—	—	
20	18	—	1075	400	—	100	
21	34	—	1700	2700	—	—	
24	14	—	625	1300	—	—	
26	24	—	1300	1400	—	—	
27	17½	—	1225	—	—	—	
28	2	—	150	—	—	—	
29	30½	—	950	800	—	—	
30	19½	—	1000	—	400	1100	Attack from Ypres, July 31st.
Aug. 1	9	—	600	—	—	—	
2	5	—	—	1400	—	—	
9	14½	—	600	1600	—	—	
10	3½	—	250	—	—	—	
12	5½	—	400	—	—	—	
13	2	—	125	—	—	—	
15	22	200	750	600	1000	—	
16	32	—	1600	2400	—	200	
17	4	—	150	600	—	—	
18	7	—	500	—	—	—	
19	5	—	—	400	600	600	
20	27	—	1850	400	—	—	
21	4½	—	150	400	200	—	
22	3	—	—	800	—	—	
23	17	150	750	700	—	—	
24	9½	—	400	1000	—	—	
25	8	—	425	500	—	—	
26	16	—	1000	—	—	600	
28	13	—	200	2800	—	—	
29	12½	—	650	700	200	—	
30	½	—	50	—	—	—	
31	40	700	1250	500	200	—	
Sept. 2	10	—	700	—	—	—	
4	½	—	—	—	200	—	
7	4	—	250	—	—	—	
8	40	—	2300	2000	—	—	
9	13	—	—	3600	—	200	
10	½	—	—	—	200	—	
12	48	—	3360	—	—	—	
13	38	—	1650	2800	—	—	
14	15	—	1100	—	—	—	
15	21½	—	800	600	800	1400	
17	3	—	200	—	—	—	
18	14	—	725	800	—	—	
19	40	500	850	1000	—	—	
22	3	—	—	—	400	400	
24	3	—	—	—	300	500	
25	12	—	750	400	—	—	
26	4	—	—	1000	—	—	
Oct. 3	18	—	1250	—	—	—	
4	102	2425	1875	1700	—	—	
5	19	—	1100	600	200	—	
6	9	—	600	—	—	—	
7	4	—	—	1100	—	—	
10	10½	—	725	—	—	—	
11	14	—	975	—	—	—	
12	4½	—	100	600	200	—	
14	13½	—	575	—	500	900	
15	9	—	600	—	—	—	
19	8	—	100	1700	—	—	
22	6	—	450	—	—	—	
25	29	—	1850	600	—	—	
26	22	—	900	1800	500	200	
28	12	—	150	2800	—	—	
29	22	—	1475	—	200	—	
31	4½	—	200	300	100	—	
Nov. 1	9½	—	650	—	—	—	
2	37	—	2450	600	—	—	
4	½	—	—	—	200	—	
5	14½	—	1000	—	—	—	
6	20	700	—	—	—	—	
7	31	—	2850	1200	200	—	
8	9½	—	150	2000	—	—	
9	26	—	1150	2700	—	—	
10	5½	—	275	200	200	—	
11	5	—	250	—	300	—	
14	10	—	650	—	200	—	
19	70¼	—	4225	—	2200	900	Battle of Cambrai.
20	9	—	525	—	200	—	
21	1¼	—	—	300	200	—	
22	8½	—	500	—	—	—	
24	8¾	—	525	—	—	—	
25	4½	—	300	—	—	—	
26	29	—	2000	—	—	—	
28	25½	—	1500	1200	—	—	
Dec. 1	9	—	—	2100	—	300	
2	9	—	600	—	—	—	
3	18	—	1000	700	200	—	
7	10	—	725	—	—	—	
11	3	—	—	—	700	—	
12	24½	—	1350	1400	—	—	
14	7	—	400	500	—	—	
15	6½	—	500	—	—	—	
1918.							
Jan.							
Feb.			Brigade in G.H.Q. Reserve.				
Mar. 11	25	—	1750	—	—	—	
17	15	—	1050	—	—	—	
19	83	—	5750	500	—	—	
20	1¼	—	100	—	—	—	
21	57	—	3728	1200	—	—	German offensive St. Quentin, Mar. 21st.
22	1¼	—	100	—	—	—	
24	¾	—	—	—	200	—	
27	37	—	2100	2000	—	—	
29	1	—	75	—	—	—	
30	22	—	1200	1400	—	—	
31	25½	—	1300	2000	—	—	
April 1	35½	—	2425	300	—	—	
5	25	—	1475	1000	—	—	
6	9¾	—	550	400	—	—	
7	10	—	700	—	—	—	German offensive Lys, April 9th.
16	5½	—	400	—	—	—	
19	17½	—	1200	—	—	—	
21	1	—	75	—	—	—	
23	1	—	75	—	—	—	
24	3	—	200	—	—	—	
25	2¼	—	150	—	—	—	
26	33	—	2200	800	—	—	
29	5	—	325	—	—	—	
May 4	8¼	—	550	—	—	—	

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TABLE I.—*Continued.*

Date.	Tons of Gas.	Cylinders.	Projector Drums.	4" S.M. Gas Bombs.	4" S.M. Smoke Bombs.	4" S.M. Thermit Bombs.	Operation.
1918.							
May 5	½	—	50	—	—	—	
6	10½	—	750	—	—	—	
7	1½	—	100	—	—	—	
8	24	—	1625	—	—	—	
9	27	—	1900	—	—	—	
12	114½	3000	2000	—	—	—	
13	1½	—	100	—	—	—	
14	1	—	75	—	—	—	
21	1	—	75	—	—	—	
23	138	3825	2000	—	—	—	
24	29	—	1800	800	—	—	
25	14	—	200	3000	—	—	
27	13½	—	900	—	—	—	
28	5	—	350	—	—	—	
31	1½	—	100	—	—	—	
June 2	9	—	600	—	—	—	
4	2	—	20	—	400	—	
7	39½	—	2325.	1600	—	—	
8	½	—	—	—	200	—	
9	142	4175	1650	—	—	—	
10	7½	—	—	500	—	—	
12	9	—	600	—	—	—	
13	7½	—	100	1600	—	—	
14	9	—	600	—	—	—	
16	90	3150	—	—	—	—	
17	41	—	1750	500	—	—	
18	10½	—	750	—	—	—	
19	13½	—	775	500	—	—	
21	3	—	200	—	—	—	
22	68½	1500	1350	1600	—	—	
24	13½	—	900	—	—	—	
25	9	—	75	2100	—	—	
26	5½	—	250	—	400	—	
27	14	—	750	—	700	200	
28	35	—	2450	—	—	—	
29	2	—	75	—	200	—	
30	1½	—	50	—	200	—	
July 1	1	—	75	—	—	—	
2	3	—	200	—	—	—	
3	20	—	850	400	1800	—	Capture of Hamel, July 4th.
5	30½	—	1975	800	—	—	
6	8	—	550	—	—	—	
9	5½	—	325	—	—	—	
10	10	—	700	—	—	—	
11	½	—	—	—	200	—	
12	168	5100	1200	1400	—	—	
18	24	—	1300	900	200	—	
20	20½	—	1375	—	200	—	
21	37	825	675	600	300	—	
22	9	—	580	—	—	—	
23	85	1750	2320	—	400	—	
24	11	—	800	—	—	—	
25	11	—	525	900	200	—	
26	4½	—	300	—	—	—	
27	14	—	625	900	—	—	
29	5½	—	400	—	—	—	

Date.	Tons of Gas.	Cylinders.	Projector Drums.	4" S.M. Gas Bombs.	4" S.M. Smoke Bombs.	4" S.M. Thermit Bombs.	Operation.
1918.							
Aug. 2	9½	—	625	—	—	—	
[redacted]	34½	—	2225	700	—	—	
[redacted]	29½	—	1600	1900	—	—	
8	8¼	—	425	400	200	—	Fourth Army Somme offensive, Aug. 8th.
9	5	—	375	—	—	—	
12	29½	—	2075	—	—	—	
14	4½	—	100	800	—	—	
16	36½	—	2550	—	—	—	
17	1½	—	100	—	—	—	
18	½	—	50	—	—	—	
19	43	1200	600	—	—	—	
20	9	—	400	1600	—	—	
21	4½	—	300	—	—	—	3rd Army offensive, Aug. 21st.
26	57	2000	—	—	—	—	
27	9	—	600	—	—	—	
28	½	—	50	—	—	—	
31	9	—	600	—	—	—	
Sept. 1	½	—	50	—	—	—	
3	14½	—	1000	—	—	—	
6	8	—	450	—	500	—	
7	2	—	125	—	—	—	
8	1½	—	100	—	—	—	
9	½	—	—	—	100	—	
10	18	—	1250	—	—	—	
11	7	—	350	600	—	—	
12	10	—	700	—	—	—	
13	12	—	675	800	—	—	
17	17	—	1125	—	300	—	
19	17½	—	1250	—	—	—	
20	5	—	350	—	—	—	
21	5½	—	375	—	—	—	
22	7½	—	375	500	—	—	
23	39	—	2550	500	100	—	
24	18	—	1250	—	—	—	
25	6½	—	200	1000	—	—	
26	10	—	700	—	—	—	
27	4	—	150	—	400	—	
28	6	—	450	—	—	—	
29	2	—	150.	—	—	—	
30	1½	—	100	—	—	—	
Oct. 1	16½	—	1175	—	—	—	
4	3	—	200	—	—	—	
5	15	—	1050	—	—	—	
6	½	—	50	—	—	—	
12	10	—	700	—	—	—	
13	2	—	—	—	500	—	
16	5	—	225	—	600	—	
Nov. 1	½	—	50	—	—	—	
2	1	—	100	—	—	—	
3	11	—	600	400	300	100	
7	½	—	—	—	—	200	

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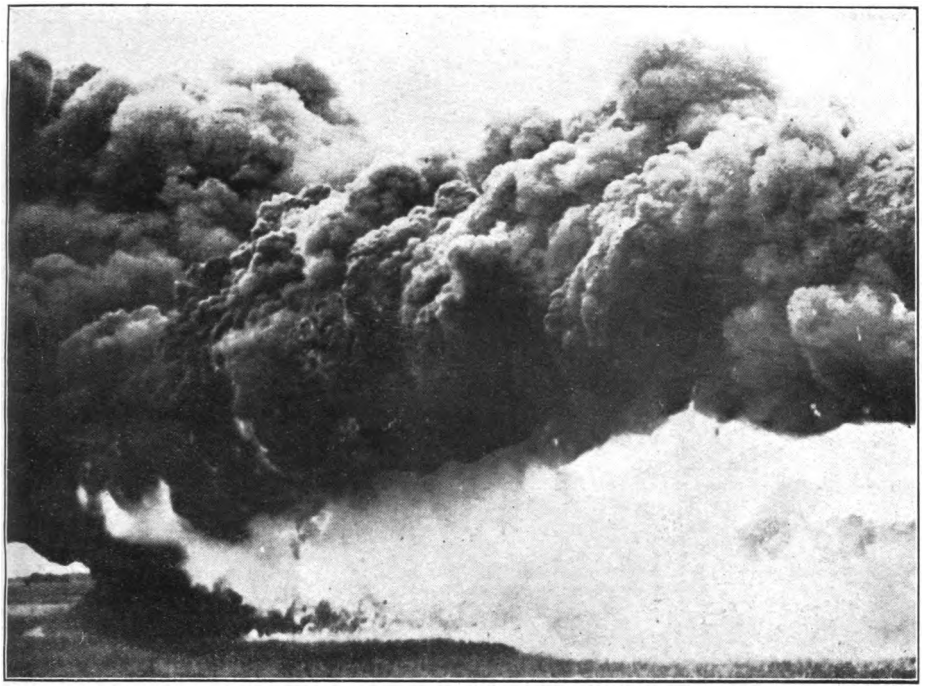

Photo I.—Flame Projectors in Action.

Photo II.—Livens Projectors being Loaded.

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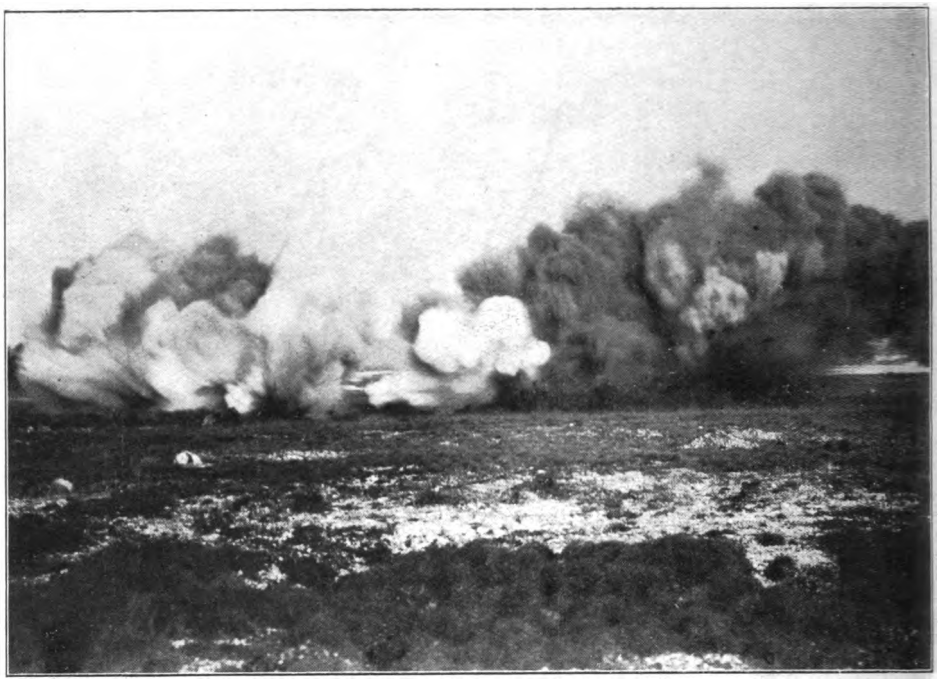

Photo III.—Bombs from Livens Projector Bursting.

Photo IV.—Enemy's Projector Installation at Boisleux-St. Marc.

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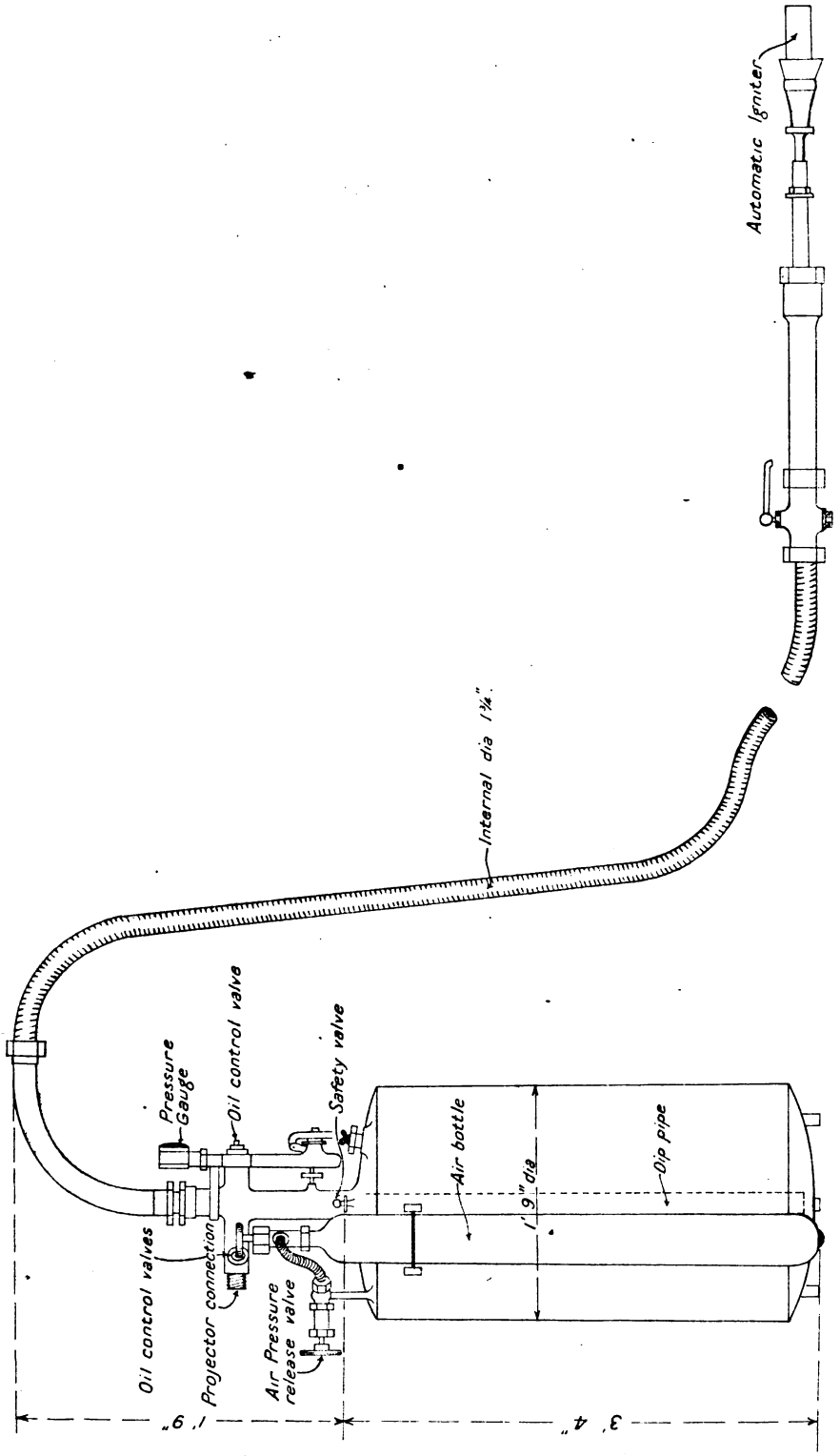
PLATE I.

SKETCH OF GERMAN FLAMMENWERFER.

Not drawn to scale.



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THE DEFENCE OF TSING-TAU, 1914.

By BRIG.-GENERAL J. E. EDMONDS, C.B., C.M.G.

THE despatches of the late Brig.-General N. W. Barnardiston, who commanded the small British force which took part with the Japanese in the operations against the late German Colony of Kiao-Chao, are very brief. Including the mentions, they cover less than seven columns of the *London Gazette* of 25th May, 1916, and they tell us practically nothing about the siege. A Japanese General Staff account, in four volumes it is said, is not yet available in England. Though as a rule the Germans write about nothing except "victories," no success no story, as has been said, an account of the defence of the naval fortress of Tsing-tau has just been published.* Its author is Konteradmiral Waldemar Vollerthun, who took part as Chief Intelligence Officer. In August, 1914, he was a Captain, and as head of the Colonial Section of the Admiralty, under which Kiao-Chao and certain other German oversea possessions were administered, was on a visit of information in China. His book is based on his diary and the official records which have been placed at his disposal, and has all the features (orders of battle, lists of batteries, maps, diagrams, etc.) of the usual German official accounts of operations; though as far as can be judged it contains fewer of the half truths which make these accounts the greatest works of military fiction in the world.

The German secret service seems to have been entirely mistaken as to the feeling in Japan in the early days of August, 1914:—"The "attitude of the Japanese people and particularly the army was "described as distinctly full of enthusiasm for Germany . . . the "people of *Bushido* had not only the wish, but the hope that the "unsurpassable German Army, the never-to-be-forgotten instructress "of Japan, would finally triumph over all its foes." The disillusion was particularly unpleasant, and the Admiral can hardly find words to express his disgust of a people who could deceive poor Germany so; "Germany to whom Japan owes practically all it possesses of "progress in *Kultur* in the European sense." He can never forgive her "brutality" for using the same words in the ultimatum as Germany used to her over Port Arthur in 1895. But he has a strong

* *Der Kampf um Tsing-tau*, Leipzig, Hirzel, 30 marks.

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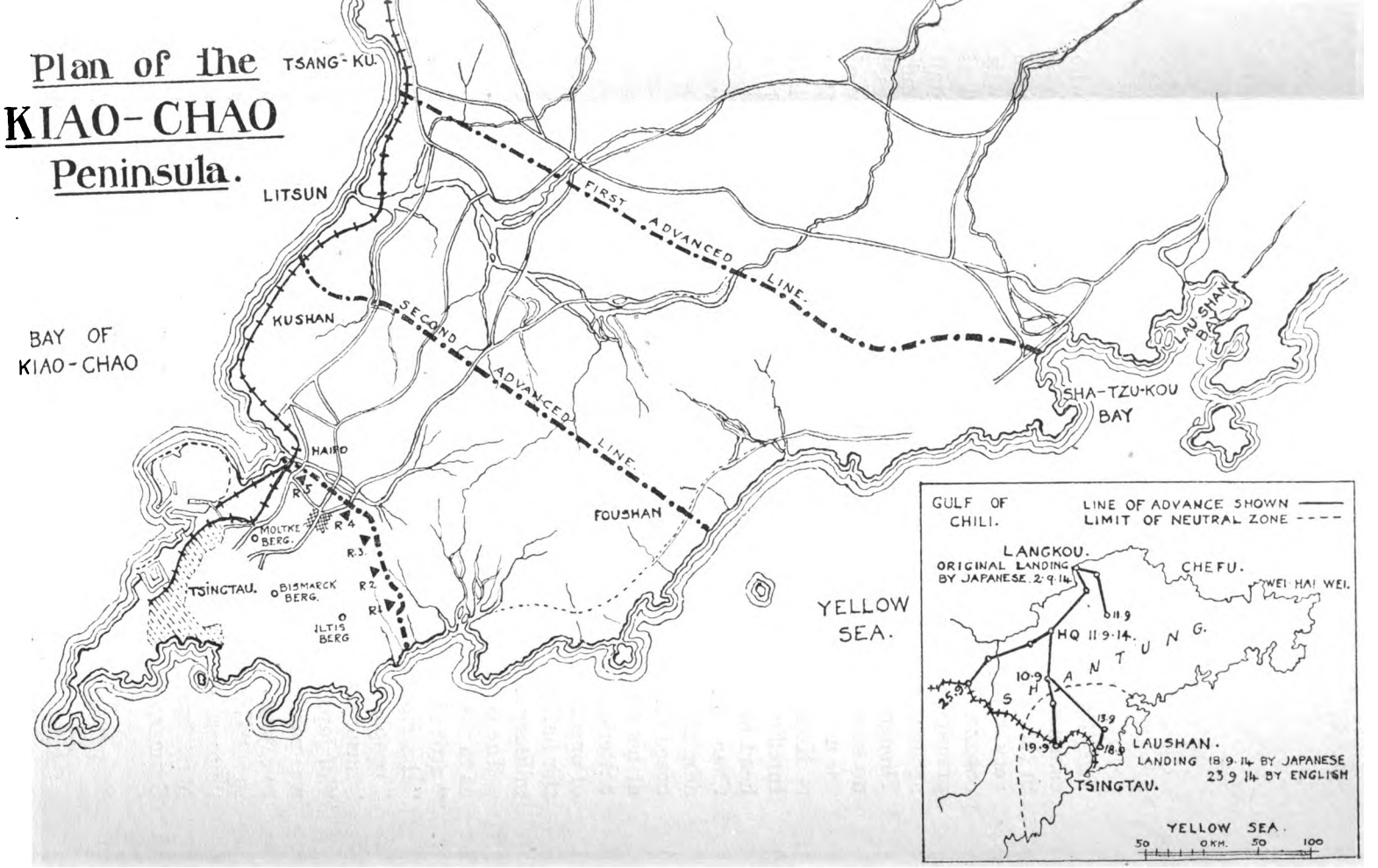

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suspicion that " London was the originator of the form of this " wonderful document."

As regards the fortifications of Tsing-tau, he says, " they were " never intended to withstand the formal attack of a large besieging " army for a long period. Their design was based on the supposi- " tion of a defence against European powers and Chinese rebels." It will be seen however that in most matters the defences were up-to-date and superior to any fortification that the Germans had to tackle in Belgium, France, or Russia.

The town of Tsing-tau is built on a promontory at the south-west corner of an area, roughly a square of some 15 miles side, which projects southward from the south-west end of the Shan-Tung peninsula, " Our Shan-tung," as the Germans used fondly to call it. On the east side of the square is the Yellow Sea, and on the west the land-locked Bay of Kiao-chao, with a three-mile wide entrance opposite the town of Tsing-tau.

The coast defences covered the outside anchorage between two headlands, south of the town, and the entrance to the Bay of Kiao-chao. They consisted of (1) one battery of four 8-inch (21 cm.) long guns, (2) one of four 5.9 inch (15 cm.) guns of most modern construction, (3) one of two 9.2 inch (24 cm.) and three 5.9 inch long guns,(4) one of four 11 inch (28 cm.) howitzers on the Bismarck-berg, a hill a little over a mile from the sea, (5) minefield batteries.

Batteries (1) (3) and (4) were concrete-built closed works, with shell-proof magazines and living casemates. The others had only shell-proof magazines. Batteries (1) and (4) could fire towards the landside as well as seawards. All the guns were in open battery.

On the land side of the town, cutting off the S.W. corner of the square and the projection on which the town stands, are four groups of hills running N.W. and S.E., separated by deep valleys ; the hills forming each group are similarly divided. The groups are narrower in width the nearer they are to the town. On the nearest group consisting of the Iltis-berg, Bismarck-berg, Moltke-berg, were most of the land batteries, with a line of Twydall redoubts from sea to sea on a subsidiary ridge below them. The upper and lower Iltis batteries had two 4-inch (10.5 cm.) QF guns, and six old 4.5 inch ; the 4-inch guns had splinter proof shields ; close by, cut in the rock, were shell-proofs, and there were also spacious shell-proof concrete magazines and living rooms.

The 11-inch howitzers on the Bismarck-berg have already been mentioned. Left of them lay a new battery with two 8-inch guns. Next came a shell-proof casemated battery for eight 5.9 inch howitzers, but with only three available. All the above batteries had been built at great expense in concrete, and were shell-proof, which was not the case with one 4.5 inch, four 3.5 inch and six 1.5 inch batteries,

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and three improvised batteries of naval guns, including two 5.9 inch. "In all, omitting the light pieces, 1.5 inch and 1.8 inch, there were "not less than 94 guns available for the defence . . . The most "efficient protection which most of the batteries had was their "concealed positions. Shell-proof armour was altogether lacking; "and no batteries were in closed works defensible against infantry "attacks." The total number of batteries of all calibres was 41. Ammunition for the small calibres was plentiful; for the heavier natures there was "no superfluity"; the figures given are: For 11 inch howitzers, 260 rounds; 9.2 inch, 230; 8-inch 320; 5.9 inch guns, 450; 5.9 howitzers, 300. There were 71 machine guns and four million rounds of S.A. ammunition.

The five Twydall redoubts in front of the batteries, closed, as has been said, the isthmus, where it was 3.4 miles (5.5 km.) across. They had been completed before war and were so well sited as to be practically invisible. They were of various sizes according to tactical requirements. The flank ones, I. and V., were the largest, and II. and III. the smallest. The plan which is given in the book has no dimensions on it except the width of the sunken wire entanglement which is 32.8 feet (10 m.); taking this as the scale, the face is 131 feet (40 m.) and the flanks are 82 feet (25 m.). There were a double storied casemate under the central parados, and shelters under the parapet, designed to resist 8-inch, but which without exception kept out all calibres even 11-inch, the roof being 4.9 inch (1.5 m.) ferro concrete, the same thickness used for "pill-boxes" in France. The garrison available for each redoubt was 260—290 men, but "the larger ones could have sheltered 1,000." The armament was 4—10 machine guns, a number of trench-mortars, and about six electric light projectors. A continuous wire entanglement ran in front of the works from sea to sea.

The author comments that the design was found unsatisfactory:— The O.P. were not sufficiently protected, and the machine guns fired over the parapet without any cover, there were no covered ways from the casemates to the parapet, and the open passage ways were soon blocked. "But the greatest weakness was the lack of a good "deep ditch with strong concrete escarp and counterscarp, well "flanked from galleries."

The total garrison of the fortress, in round figures, counting the reservists, etc., who arrived from up-country, was 144 officers and 3,600 men. The warships in harbour, which assisted in the defence from the bay were the gunboat *Jaguar*, with four 3-inch guns, torpedo boat N 90, and the Austrian cruiser *Kaiserin Elizabeth*, with six 5.9 inch.

There being abundance of Chinese labour, the improvement of the defences was carried on without pause. Between the infantry

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redoubts several lines of strong points connected by traffic trenches were dug ; and to give the position depth a system of splinter proof blockhouses was built behind the intervals of the redoubts. Six batteries of two 3.5 inch guns were also constructed to cover these intervals with fire, and another pair of these guns was mounted on a truck on the railway which passed through the left of the line ; and machine gun nests and short lengths of trench were scattered over the ground in well-concealed positions.

Further, two advanced positions were prepared on the nearest two lines of hills in front of the main position :—The first from Sha-tzu-kou Bay to Tsang-ku, 12 miles from the town, where the peninsula is about 11 miles wide ; and the second from Fu-shan to Ku-shan, six miles from the town, where the peninsula is about 7½ miles wide. " Originally hasty fire-trenches, they had become strong field positions " with wire entanglements, minefields, dummy positions, emplace- " ments for field batteries. The Tsang-ku heights were specially " well defended," as they covered the approach roads on the left. " The right of the second line was particularly strongly provided with " artillery," and an important observatory with an all-round view was constructed on Fu-shan.

On the evening on the 25th August there was a terrific typhoon rainstorm which did an immense amount of damage to the defences, made a breach in the dam of the waterworks at Litsun outside the main defences, and flooded the machinery room of the bombproof waterworks, for war use, at Hai-po. But the effect on roads and communications placed such obstacles and difficulties in the way of the advance of the attackers that the destruction done by the storm was, taking it all round, greatly in favour of the Germans.

The Japanese commenced landing on the 2nd September at Lung-kou on the northern side of the Shan-tung peninsula, 112 miles north of Tsing-tau. The force was believed to be a division, under General Kamio.

By the 17th they had reached the frontier of the Protectorate, 16 miles from the town. Admiral Vollerthun complains of " the slow march of the Japanese and their careful, from-all-surprise-and-ruse-enterprises-free, pedantic methodical ways," and abuses them as " yellow dwarfs " (*gelbe Zwerge*). On the 18th however the Admiral should have been satisfied with their enterprise, for they made a surprise landing at Lau-shan Bay on the eastern side of the Protectorate, and not far outside the right flank of the outer defences. " Our weak patrols in the plain before Lau-shan had soon to clear " out in order not to run the danger of being cut off by superior " force." Lau-shan now became the main Japanese base, and the British contingent, the 2nd South Wales Borderers from Tientsin,

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landed there on the 25th September, followed on the 22nd October by a half-battalion of the 36th Sikhs.

The Germans put up a poor fight in their advanced positions. The Japanese commenced their forward movement on the 26th September, with apparently two columns from the north and one from the east, against the first position, and the Germans immediately retreated to the second. In this they made a short stand, with the assistance of the guns of the war ships on the left flank. But the ships were driven off by Japanese aeroplanes, and as the Japanese commander was making preparations for assault, in which the British contingent was to have taken part, the German governor gave the order for retreat into the fortress. Admiral Vollerthun now complains that the enemy was guided by Chinese, who pointed out where the minefields were, in fact marked each mine with a white stone. In these preliminary moves the Germans lost less than 100 men, including 2 officers and 50 men captured in the forward lookout station. The author considers the shooting of the Japanese infantry was of small account (*minderwertig*); he admits later on however that they were superior to the Germans in night operations.

The Governor now appears to have lost heart, although he had received a wireless message:—"His Majesty has ordered that "Tsing-tau is to be defended to the last." He had "three great "yawning pits dug, one in the cemetery, and the others right and "left of it. They were mass-graves for the expected casualties"; and he began to think of the irreparable loss it would be to *Kultur*, if all the Germans who had intimate knowledge of China trading were killed. The torpedo boat was ordered to escape and ran itself ashore, the other ships were sunk at various dates, the *Kaiserin Elizabeth* on the 1st September. Meanwhile under constant fire of the guns of the defence the Japanese prepared batteries for their 28 cm. howitzers; the Germans had only one aeroplane at their disposal, but this at any rate was more than General Leman of Liége possessed.

The bombardment began at daybreak on the 21st; the infantry redoubts were "knocked out of recognition and usefulness . . . great breeches were made in the wire . . . the blockhouses were nearly all destroyed." Only one open but well concealed 5.3 inch battery remained undamaged and undiscovered. On the night of the 30th September-1st October a first parallel with approaches to a second was made by the Japanese. On the night of the 1st-2nd the second parallel was dug. An attempt to storm infantry redoubt IV. is said to have been repulsed. Meantime the bombardment continued and on the 4th it was extended to the town, warships assisting from the south west, under protection of Cape Jäschke. On the same day the advanced works on the right and left of the line and the

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waterworks defences were captured (the garrison was then reduced to well water) and sounds of mining in the rock under the infantry redoubts were heard. On the night of the 5th-6th attempts of the Japanese to break through on the left of infantry redoubt IV. and over the mudflats of the inner bay on the extreme left are said to have failed. On the night of the 6th-7th the Japanese made a general assault :—Redoubt III. was captured at 2 a.m., II. and IV. by 5.30 a.m. ; at 6 a.m. the storm of I. was commenced, and artillery fire concentrated on V. At 6.20 a.m. the white flag was seen to be hoisted on the Observatory and Signal Station, but it was 7.30 a.m. before the last shot was fired.

The author claims that the Japanese losses were over 5,000, and declines to believe the official figures of 1,800 killed and wounded. The total German losses were, he says, 199 killed and 500 wounded, 16 per cent. of the garrison. There is the usual curious whine of the defeated German that his opponents were drunk ; in this case *heftig unter Alkohol stehend* when they entered the town, and that they plundered and stole. The final piece of spitefulness that this German officer indulges in to relieve his feelings is that " the Japanese officers spoke of their English allies in a contemptuous way. For the attack they always sought the safest places."

From various sources it is stated that the besieging army consisted of 50,000 men and the artillery of six 11-inch howitzers, six 9.1 inch howitzers, 36 field guns, 18 mountain guns, four 4.7 inch and four 5.9 naval guns, and that during the seven days bombarding 43,500 shells were fired at the fortress.

The defence of Tsing-tau as regards both its conception and execution is not a creditable episode to German arms, and in no wise comparable with the resistance of Liége, Maubeuge, or Antwerp. Tsing-tau was a modern fortress, its 4.9 feet thick concrete shelters were, as the author boasts, shell proof against the Japanese 11-inch howitzers, and even against 12-inch. " A 12-inch shell struck the " concrete of a magazine at the extremely steep angle of about 60°. " The cover was only 4.9 feet thick and yet the force of the explosion " could not destroy it. There were only radiating cracks made, " and a crater shaped hole outside about 20 inches deep." At Liége, Maubeuge, and Antwerp there was not a single shelter that was shell-proof available even for headquarters that would resist the German 16-inch (42 cm.) shells. At these three old fortresses the attackers' batteries outranged the defenders' and could not be touched, whilst at Tsing-tau the German guns, the author again boasts, not only engaged but knocked out the Japanese.

At Liége a Zeppelin commenced the bombardment on the night of the 4th-5th August (see German General Staff account) and the heavy artillery on the 6th-7th ; the last fort did not surrender until

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the 17th ; there was at least 10 days' bombardment. At Maubeuge the bombardment with 16-inch and 12-inch howitzers was opened on the 29th August, and the fortress capitulated on the 7th September (von Zwehl) ; there was at least nine days' bombardment ; Antwerp held out 12 days (28th September—9th October). Tsing-tau with its superior protection and armament held out only seven days against howitzers of only 11-inch calibre, just as long as the entirely obsolete fortress of Longwy (22nd-28th August, *vide* Stegemann).

Until the exact number of heavy howitzers employed and the amount of ammunition fired is known, a final opinion of the defence made by the Germans cannot with fairness be given.

It would be of interest to know what reception the Governor received from his superiors when he returned to Germany.

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PROFESSIONAL NOTES.

QUALIFYING EXAMINATION FOR THE MECHANICAL SCIENCES TRIPOS, CAMBRIDGE UNIVERSITY.

THE following synopsis of the examination and two specimen papers are published by permission.

SYNOPSIS.

MATHEMATICS.—3 HOURS.

Use of slide rule and graphs; elementary algebra, including the use of the binominal theorem, the exponential theorem, and logarithms. Elementary trigonometry, including the solution of plane triangles. Representation of directed quantities by vectors. The rudiments of plane analytical geometry, including the simpler properties of conic sections referred to rectangular axes, but excluding the general equation of the second degree. Use of the elements of the differential and integral calculus, elementary applications to plane curves, *maxima* and *minima* of simple functions of one variable, easy areas and volumes, expansions of simple functions.

MECHANICS.—3 HOURS.

(*It is necessary to satisfy the examiner in both Statics and Dynamics separately*).

Units: composition and resolution of forces, treated analytically and graphically: conditions of equilibrium: force diagrams: friction. Graphic methods of representing motion, including varying acceleration. Force, momentum, work energy, power: conservation of momentum, conservation of energy; efficiency of machines: uniform circular motion: simple harmonic motion: moment of inertia: rotation and oscillation of solid bodies about a fixed axis.

NOTE.—In both papers it is usual to set from 12 to 15 questions of which answers are only required to 10.

Papers set at a recent Examination.

MATHEMATICS.

Answers are not expected to more than **ten** *questions.*

1. For use in solving certain problems, a slide rule is constructed with an extra top scale, the numbers on which give the values of the numbers immediately under them on the bottom scale raised to the

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power of 1·4. If the bottom scale reads from 1 to 10 and is 10 inches long, calculate the distance between the divisions marked 4 and 6 on the extra top scale. Also explain how you would obtain the value of $0{\cdot}2^{1{\cdot}4}$ by means of such a slide rule.

2. Express $\dfrac{x^2(x^2+1)}{(x+1)(x^3+1)}$ in Partial Fractions.

3. Find graphically the positive value of x which satisfies the equation

$$3 \sin x + \cos x = x.$$

4. The motion of a car is assumed to follow the law $xy = a - bx^2$ where y is the rate of increase of velocity with distance and x is the velocity, a and b being constants. Observed values of x and y are given in the following table :

x	6·3	10·5	14·1	17·6	19·7
y	2·94	1·33	0·71	0·23	0·04

Allowing for errors of observation, find by a graphical method the most probable values of the constants a and b.

5. Write down the expansion of $(1+x)^n$ in ascending powers of x and show that when x and y are small,

$$\frac{(1+x)^n}{(1+y)^m} = 1 + nx - my \text{ approximately.}$$

The profits of a mill are found to be proportional to $\dfrac{N^{\frac{3}{4}}}{P^{\frac{1}{2}}}$ where N is the number of machines and P the number of workmen employed. Find approximately the percentage increase in profits when the number of machines is increased by 1 % and at the same time the number of workmen is decreased by 3 %.

6. In a $\triangle ABC$, $AB = 12''$, $AC = 10''$ and the $\angle BAC = 15° 14'$. Find the length of BC and the remaining two angles. Find also the magnitude and nature of the error in the calculated value of BC which would arise from an error of 1 % in the measurement of AC.

7. Prove that $\tan(\theta - \theta') = \dfrac{\tan\theta - \tan\theta'}{1 + \tan\theta \tan\theta'}$.

Hence find the angle between the straight lines whose equations are $3x + 4y + 5 = 0$ and $2x - 3y + 6 = 0$.

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8. Differentiate with respect to x:

(1) $\tan^{-1}(e^x \cos ax)$,

(2) $\log_e \sqrt{\frac{1 - \cos x}{1 + \cos x}}$,

(3) $\left(\frac{1 + \sqrt{x}}{1 - \sqrt{x}}\right)^{3/2}$.

9. Prove that for the parabola $y^2 = 4ax$, the subnormal is of constant length.

10. In a submarine telegraph cable, the speed of signalling is found to vary as $x^2 \log \frac{1}{x}$ where x is the ratio of the radius of the core to that of the covering. If the radius of the core is $\frac{1}{2}$ inch, find the radius of the covering in order that the greatest speed of signalling possible may be attained.

11. Prove that if $y = Ae^{-kt} \cos(pt + B)$ where A, B, p and k are constants, then

$$\frac{d^2y}{dt^2} + 2k\frac{dy}{dt} + n^2y = 0,$$

where $n^2 = p^2 + k^2$.

12. Integrate with respect to x:

(1) $\frac{x}{x^2 + 6x + 8}$; (2) $\frac{1}{\sqrt{x - 1}}$; (3) $x \tan^{-1} x$.

13. The generating curve of the inside of a barrel consists of a parabola whose equation referred to the centre of the barrel as origin and a maximum radius as axis of x, is given by $y^2 = k(a - x)$, where k is constant. Prove that if the internal length of the barrel and the radius at either end be h and b respectively, the volume of the inside is given by

$$\frac{\pi}{15}\{8a^2 + 4ab + 3b^2\}h.$$

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MECHANICS.

Candidates are not expected to show up solutions to more than **ten** *questions, but must satisfy the examiners in* **both** *parts of the paper.*

PART I. STATICS.

1. A uniform plate in the form of an equilateral triangle of side 3 ft and mass 6 lbs. is free to swing in a vertical plane about a fixed axis through the mid-point of AB. To A and C are attached strings of lengths 2 ft. and $2\frac{1}{2}$ ft. respectively whose other ends are attached to a mass of 4 lbs.

Find grapically or otherwise the angle which AB makes with the vertical in the position of equilibrium.

2. Fig. (1) shows the end view of a roof.

On the planes AC and DE wind pressures of 10,000 lbs. wt. and 3000 lbs. wt. respectively are acting, whose lines of action may be taken as normal to the planes and passing through their mid-points.

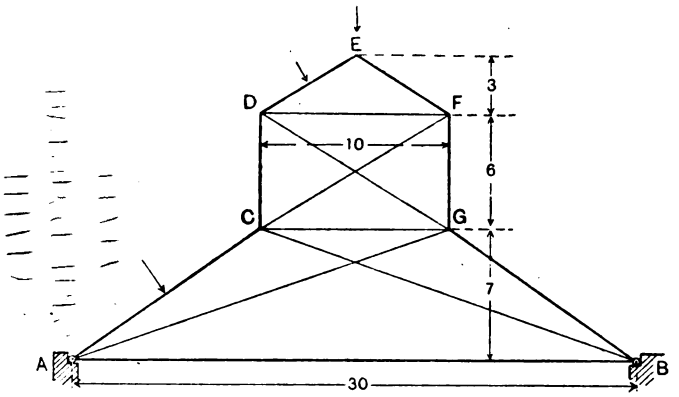

FIG. 1.

The roof is symmetrical and weighs 20,000 lbs., the dimensions in feet being as shown.

If the reaction at A is known to be vertical, find the magnitude and direction of the reaction at B.

(A graphical method of solution is preferred).

3. Draw a diagram to show the stresses in the bars of the loaded framework in Fig. (2), consisting of light rods pin jointed at their extremities and hanging from A and B.

The reactions at A and B are vertical.

Mark the rods which are in compression.

[Transfer the figure by pricking through.]

4. A uniform bar of length 15 ft. and mass 60 lbs. rests on a rough peg with one end against a rough vertical wall. The angle of friction

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between the surfaces in contact is 10°. Find graphically or otherwise the two distances which the peg may be from the wall, if the bar is just in equilibrium when making an angle of 50° with the vertical.

5. A heavy cubical box of side 3 ft. is dragged at a uniform rate along a level passage with vertical walls just over 3ft. apart. The box weighs 100 lbs. and its centre of gravity is 9 inches from a wall of the passage.

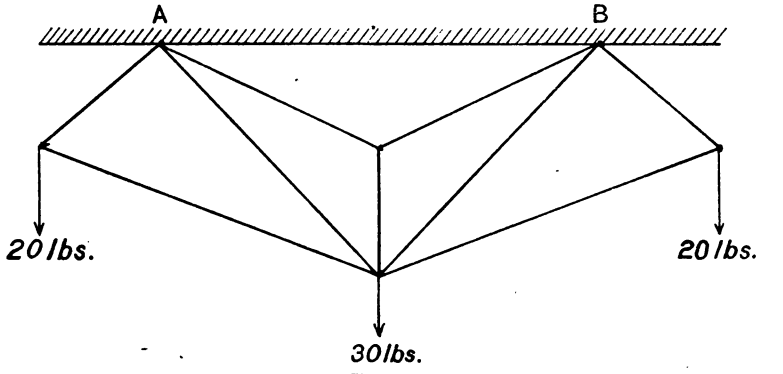

FIG. 2.

Find the pull required if it is applied horizontally in the central vertical plane of the passage. The coefficient of friction between the box and the floor or walls of the passage is 0·3.

6. Distinguish between the "instantaneous efficiency" and "average efficiency" of a mechanism.

The crank AB in Fig. (3) is driven counter clockwise forcing the cross-head C, which slides on the guide DE, against a thrust F of 5000 lbs. wt. acting in the direction CA. The coefficient of friction between cross-head and guide is 0·3.

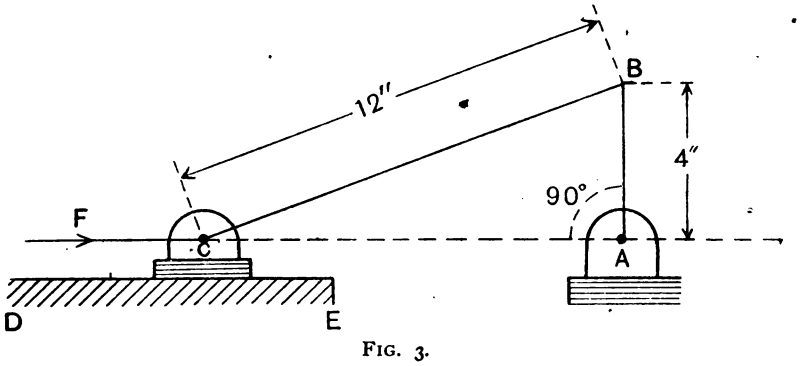

FIG. 3.

Find the efficiency of the mechanism in the position shown in Fig. (3), neglecting friction in the bearings at A and B.

7. Find the position of the centre of gravity of the sheet of metal

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in Fig. (4). The diameter of the circular hole is 2ft., and its centre is $1\frac{1}{4}$ ft. from the nearest sides.

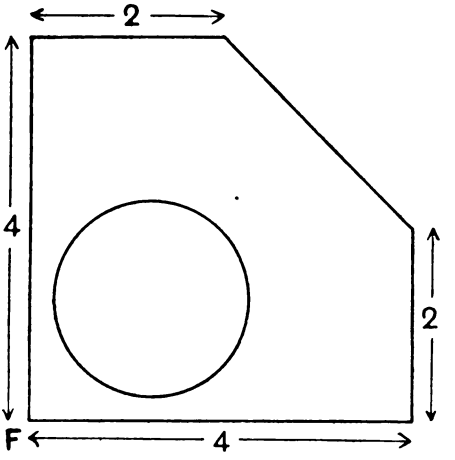

FIG. 4.

PART II. DYNAMICS.

8. Show that if V be the speed and S the distance travelled from some fixed point in the path of a moving body, the slope of the graph of $\frac{V^2}{2}$ plotted to a base of S gives the acceleration of the moving body along its path.

Observations of velocity and distance from the starting point of a car are as follows:

V	0	12·6	16·7	19	21·4	23·2	23·6	f. s.
S	0	30	65	100	160	250	300	ft.

Find the initial acceleration, and the H.P. being exerted at 160 ft. from the start if the car weighs 1 ton and resistance to motion is 100 lbs. wt.

9. A balloon weighing 1200 lbs. is found to be descending and in two consecutive minutes the distances fallen are calculated to be 240ft. and 600 ft. respectively. Find the amount of ballast that must be suddenly released in order that it may rise 240 ft. in the next two minutes. The acceleration may be taken as uniform both during descent and ascent.

10. The bar of a goal is 10 ft. above the ground level. A ball is kicked from a distance of 30 yards so as to leave the ground at an angle of 30° to the horizontal. Neglecting air resistance, find the least initial velocity which must be given to the ball in order that it may just clear the bar.

11. A machine gun is fired backwards from the rear of an armoured car at the rate of 600 rounds per minute. The mass of

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each bullet is $\frac{1}{2}$ oz. and muzzle velocity 2200 f. s. Find the driving power added to that of the car when the car is travelling at 40 m. h.

12. A football player weighing 10 stone and running at 15 m.h. overtakes and collars another weighing 13 stone, and running at 12 m.h., the angle between their directions of motion being 30° at the moment of collaring. Find the magnitude and direction of their common velocity immediately after the impact, and the impulse which either receives.

13. A bullet, of mass 3 oz., moving with a velocity of 2200.f.s. strikes a ballistic pendulum of mass 15 lbs. and remains embedded in it. Calculate the percentage of kinetic energy converted into heat, and the average resistance to penetration if the bullet comes to rest after penetrating 5 inches.

14. Define Simple Harmonic Motion.

If a point moves with S.H.M., show that the graph connecting its velocity with distance along its path may be represented by a circle, if a particular scale is chosen for the velocity ordinate.

Show also that, during motion from one end of the travel to the other, the mean velocity with respect to the distance is $\frac{\pi}{4} \times$ the maximum velocity, and with respect to the time is $\frac{2}{\pi} \times$ the maximum velocity.

15. Two cog wheels, having respectively 50 and 100 teeth and moments of inertia 10 and 50 lbs. ft.^{2} units, are in gear. The larger wheel is driven by a light spiral spring which exerts a torque of 0·5 lb. ft. per revolution through which it is twisted.

If the spring be wound up through 10 turns initially, and the system be then let go, find the maximum speeds which the wheels would attain if they ran smoothly and without friction.

TEXT BOOKS RECOMMENDED BY THE STAFF OF THE ENGINEERING LABORATORY.

Qualifying Examination and First Year Tripos Course.

Subject.	*Author.*	*Title.*	*Publisher.*	*Price.*
Mathematics	Perry, J.	Elementary Practical Mathematics	Macmillan	7/–
,,	Thompson, S. P.	Calculus made easy	Macmillan	3/–
,,	Carslaw, H. S.	An introduction to the infinitesimal Calculus	Longmans	6/6
Statics	Fawdry, R. C.	Statics, Parts I. and II.	G. Bell and Sons	5/–
Mechanics and Mechanics of Machines	Landon, J. W.	Elementary Dynamics	Camb. Univ. Press	10/6
	Duncan, J.	Applied Mechanics for Engineers	Macmillan	10/6

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Subject.	*Author.*	*Title.*	*Publisher.*	*Price.*
Electricity	Yorke, J. Paley	Applied Electricity	Arnold	8/6
Properties of Materials.	Charnock, G. F.	Mechanical Technology	Constable	10/-
Surveying	Whitelaw, J., jun.	Surveying	Crosby Lockwood	10/6
Drawing	Spooner, H. J.	Machine Design, Constructional Drawing	Longmans	21/-

Second and Third Year Tripos Course.

Subject.	*Author.*	*Title.*	*Publisher.*	*Price.*
Mathematics	Lamb, H.	Infinitesimal Calculus	Camb. Univ. Press	20/-
Mechanics	Duncan, J.	Applied Mechanics for Engineers	Macmillan	10/6
,,	Worthington, A. M.	Dynamics of Rotation	Longmans	6/6
,,	Inglis, C. E.	Examples in Applied Mechanics and Elementary Theory of Structures	Camb. Univ. Press	3/-
Heat	Ewing, J. A.	The Steam Engine and other heat Engines	Camb. Univ. Press	16/-
,,	Wimperis, H. E.	The Internal Combustion Engine	Constable	8/6
,,	Peel, T.	Examples in Heat and Heat Engines	Camb. Univ. Press	5/-
Electricity	Hay, A.	Continuous Current Engineering	Constable	9/6
,,	James, W. H. N.	Alternating Currents in Theory and Practice	Camb. Univ. Press	12/-
,,	Lamb, C. G.	Notes on Magnetism	Camb. Univ. Press	5/-
,,	Lamb, C. G.	Examples in Applied Electricity	Camb. Univ. Press	3/-
,,	Gill and Teago	Examples in Electrical Engineering	Arnold	-
Theory of Structures	Ewing, J. A.	Strength of Materials	Camb. Univ. Press	12/6
Properties of Steel	Edwards, C. A.	The Physico-Chemical Properties of Steel	Griffen	21/-
Hydraulics	Lea, F. C.	Hydraulics	Arnold	18/-

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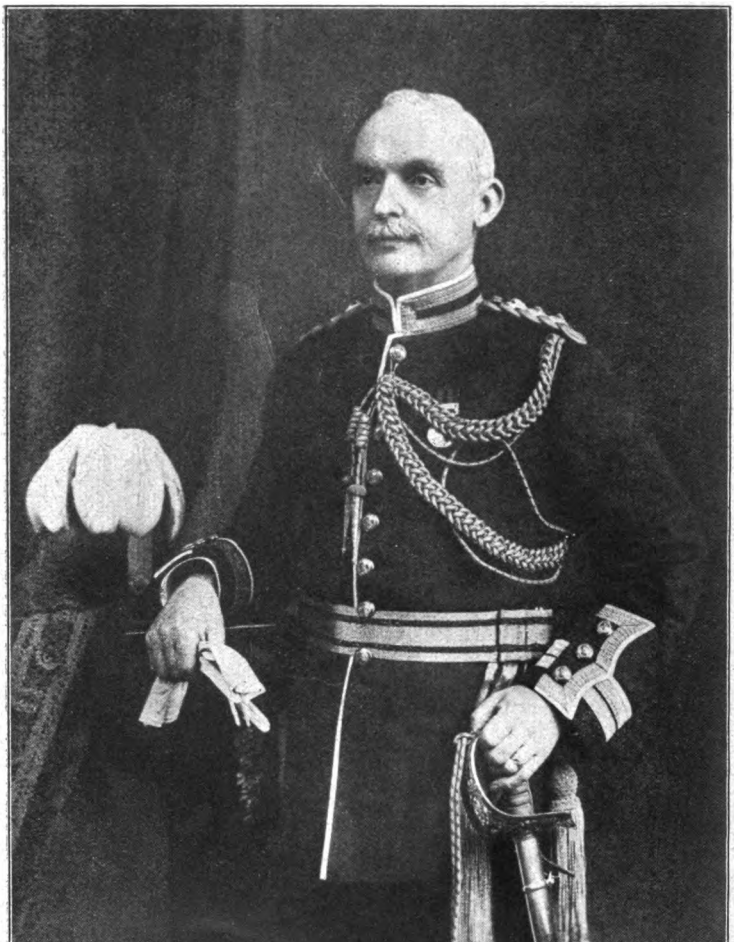

Brig.-General Sir Francis Anderson, K.B.E., C.I.E.

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MEMOIR.

BRIGADIER-GENERAL SIR FRANCIS JAMES ANDERSON, K.B.E., C.B.

SIR FRANCIS JAMES ANDERSON, K.B.E., C.B., of Ballydavid House, Rossduff, Waterford, whose loss the Corps has to deplore, at the comparatively early age of 60, was born in Edinburgh on the 17th February, 1860. He was the fourth son of Deputy Inspector General of Hospitals Robert Carew Anderson, of Suir View, Kilkenny, of the family of the Andersons of Gracedieu, Co. Waterford, descended from the Andersons of Wester Eyrederbeck, in Aberdeenshire; and of his wife, Jane Wallis, daughter of the Rev. Henry Bolton, vicar of Dysart Enos, Queen's County.

Anderson was educated abroad and passed into the Royal Military Academy at the age of 16½ in September, 1876. He passed out tenth on the list in July, 1878, his commission in the Royal Engineers, as was then the custom, being antedated to the 31st January, 1878.

While at Chatham he was an enthusiastic member of the R.E. Yacht Club and made many cruises in the old *Buccaneer* and *Violet*, crossing occasionally to France and coasting round the south of England. He was keenly interested in navigation and wrote a pamphlet on Elementary Lessons in Nautical Astronomy. The fortification tour on which his batch was taken while under instruction necessitated visits to the Portsmouth and Isle of Wight defences and the batch hired a yacht for the visits to Yarmouth, Hurst Castle, Southampton and Ryde, the navigation being undertaken by Capt. Bogle and Anderson.

On quitting the S.M.E., Anderson, after the usual leave, was posted to the 18th Company, R.E., and, amongst other duties, served with the Cork flying column from January to April, 1881, in the suppression of the Mitchelstown disturbances.

In 1881 he volunteered for service on the Indian Establishment and embarked at Queenstown in the *Malabar* on the 10th December. The monotony of the voyage out was relieved by detention for two days in the Suez Canal, a liner ahead having gone aground. There was a pack of hounds on board going out to the Peshawar Hunt and these were taken ashore on the sandy banks of the Canal on Christmas Day for a jackal hunt. There was no sport,

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but the exercise was refreshing to both hounds and men. On reaching India Anderson was attached to the 1st (K.G.O.) Sappers and Miners first at Roorkee and afterwards on detachment at Rawal Pindi, until posted to the Military Works Department, which he joined in June, 1882, at Peshawar. In November, 1884, he was transferred to the 2nd Queen's Own Sappers and Miners at Bangalore, being posted to B Company. On the outbreak of the war against Theebaw in 1885 he was sent with C Company, which he was then commanding, to Rangoon in October, and proceeded with the river column and was at the taking of Fort Minhla and of Mandalay in November, 1885. The company was employed thereafter in various flying columns sent out to pacify the country. For this campaign he received the Frontier medal with clasp.

In December, 1885, he was appointed Adjutant of the 2nd (Queen's Own) Sappers and Miners, but was prevented from taking up the appointment immediately by a dangerous attack of Peshawar fever which confined him to hospital for three months and necessitated nine months' sick leave to England. During his leave he married Frances Alice, daughter of Major O'Gorman, of the 90th Light Infantry, sometime M.P. for Waterford. On the termination of his leave Anderson and his wife sailed for India in December, 1886, and he took up his duties as Adjutant, Colonel A. F. Hamilton being at that time Commandant.

In 1888 Anderson, having completed his seven years on the Indian Establishment, reverted to home duty and was posted to Portland as Division Officer in December, 1888. He was promoted to Captain on the 18th of that month. His work there brought him into touch with convict labour, which was employed on the defences and barrack building under his charge and caused his large heart to take a kindly interest in the troubles and history of some of these unfortunate men, especially in the case of young fellows who had been tempted and bitterly regretted what they had done. Anderson spent much of his leisure time while at Weymouth in his favourite pastime of yachting. He owned and sailed the *Gazania*, and made many voyages round the coast east and west, occasionally running over to Havre and Cherbourg. The crew on these occasions consisted of himself and one deck hand.

Anderson's mathematical and analytical brain drew him early in life to a deep study of cryptography in which he became an expert and an authority. In 1887 he published a pamphlet, " Remarks on a method of deciphering Cryptograms," and also contributed articles on the subject to *The Pioneer*, and had besides written many notes and collected much information on this interesting subject. He was the means, while at Weymouth, of discovering and preventing an outbreak in the convict prison at Portland, by reading a cypher which had been intercepted. He used to amuse himself by answering

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cypher communications in the agony columns of the papers to the extreme annoyance of the people who put them in. His work was known to the military authorities and led to his being asked to serve from time to time, while at Weymouth, on committees of the Intelligence Division engaged on examining systems of cryptography and compiling code and handbooks for military use. His knowledge was later to prove of immense value to the country in time of war.

In 1892 Anderson was offered and accepted the post of Deputy Colonial Engineer at Penang, and, in 1894, President of the Municipal Commission at Georgetown, the late Sir Henry MacCallum being at that time Colonial Engineer of the Straits Settlements. While at Penang it fell to Anderson's lot to ascertain the cause of, and to remedy a serious leak in the great reservoir at Waterfall. This he accomplished with success. During his tenure of office a scheme for the harbour improvements at Penang was in course of preparation and he was responsible for the improved design for the new pier which was adopted on his advice and recommendation. Under his direction the detailed survey of the territory was advanced and improved and complete new revenue sheets were prepared and issued. He designed and built a bungalow for himself on Penang Hill. Later in his service in the Straits he acted as Colonial Engineer during the absence of Sir Henry MacCallum and was sworn a member of the Executive Council on the 18th March, 1896. He was also a member of the Legislative Council.

His promotion to Major came on October 10th, 1896, and in August, 1897, he returned to duty in England and was posted to Aldershot, when he was employed on barrack reconstruction and on the electric lighting of the barracks. Colonel Pitt, his C.R.E. at that time, writes:—

"He was an extraordinarily capable man all round and an unusually good mathematician. Whilst he was at Aldershot we were getting out a large scheme for the electric lighting of the whole place, including the design for the generating station and laying all the cables, as well as wiring all the buildings. This involved a great deal of highly complicated calculation which Anderson entered into *con amore* and carried out most successfully. The 'three wire' system was adopted and, as no adequate text-book was forthcoming, he had to work out his own formulæ."

In 1899 Anderson was transferred to Clonmel and served there and at Waterford as reconstruction officer of the Cork district. His stay in Waterford with his family was a happy and uneventful time. His service there covered the period of the war in South Africa. In the course of these operations cypher messages from the Boer Government were intercepted and Anderson's special knowledge was requisitioned with a result that the Boer code was discovered and the messages de-coded. For his success on this and other occasions

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he was rewarded with a gratuity of £100—though brevet promotion was refused.

In June, 1904, he was promoted Lieut.-Colonel and again ordered to India, and, landing at Bombay in February, 1905, proceeded to Secunderabad for a few weeks until he took up the command of the 2nd Queen's Own Sappers and Miners, of which he had been Adjutant seventeen years previously. This was a busy and a happy time for him, as the Command was one for which he was well fitted, giving scope to his inexhaustible energy, initiative and cheerfulness. He did much during the four years he held the Command to improve the military and technical training of the Corps. He started a provident fund for the widows and orphans of the British Warrant and N.C. Officers attached to the Corps. He was instrumental in forming classes of instruction in military engineering for officers of other arms of the Service, for which there were exceptional facilities at Bangalore.

This was the period of Kitchener tests, and Anderson was fully alive to the importance of sapper companies being exercised during training and manœuvres in conjunction with other arms. He did much to assist in the framing of training programmes and to instil reality in the schemes for the annual training of the Bangalore Brigade. A portion of one year's Brigade training was devoted to an unusually complete lesson in entrenching. The corps was inspected by Lord Kitchener during Anderson's tenure of the Command.

His recreation during this time was shooting, and at week-ends and whenever work allowed he would bicycle for miles in the heat to his favourite snipe jheels and covers for a day in the open air with his gun.

Major-General Sir Francis Bond writes:—"For some years it was my privilege, as D.G.M.W. in India, to inspect my old Corps, the Queen's Own Sappers and Miners, when Anderson was in command, and I am always glad to think that I was instrumental, knowing of his excellent reputation, in getting him his appointment.

I can testify to the ability and zeal with which he commanded the Corps, and actively supported its high reputation. Beloved by his officers and men, he never failed to keep up a vivid interest in the technical and field work, and he always encouraged real comraderie with other troops in the Bangalore Brigade. With him work and fun went hand in hand, and amongst his many official duties and interests, time was always found for running a merry little paper, called "Camp Pie," which created much laughter amongst his comrades and friends in the Corps and the Brigade.

Later on in the days of the Great War, we were together in the War Office, and Anderson's ready assistance and unfailing grasp of sanitary conditions and up-to-date methods, immensely eased the strain of the Quartermaster General's branch which was charged

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with the housing and billeting of all troops, and the provision of camps and hospital accommodation for the United Kingdom. In every part of this work, we consulted Anderson and his committee and always with advantage.

All this time he was conducting other work of intense value to the Intelligence in his General Staff capacity, and all with the same marked ability and thoroughness, maintaining the same admirable spirit as ever amongst his colleagues and friends. He took a keen interest in the R.E. Charitable Fund, and his loss to that committee as well as to the wider interests of the Corps, is very great.

Anderson's work throughout the time I knew him was full of energy devoted to the betterment of the interests of others, and the public service. He never thought of himself, or urged claims of his own."

An Officer (Major Berkeley Hill, I.M.S.) who served with him at Bangalore writes :—" General Anderson was one of the most gifted and delightful men I have ever known. He was my first C.O. and a better, kinder, or more lovable C.O. no man could have had than I had in the Commandant of the Q.O. Sappers and Miners. His loss will be deeply felt by all those whose privilege it was to work with him or under him, and among such mourners will be many Indians as well as Europeans."

On the termination of his period of command in June, 1909, he returned home, being promoted substantive Colonel and appointed A.D.F.W. at the War Office in August of that year. He also became *ex-officio* member of the Army Medical Advisory Board. Among other duties at this time he was engaged in compiling a memorandum on cryptography and codes and many of his suggestions were adopted in the official handbook.

In January, 1913, he was appointed Chief Engineer of the Eastern Command with the honorary rank of Brigadier General. He was serving in this Command when the war broke out; and he was at once recalled to Army Headquarters and attached to the General Staff as Chief Cypher Officer for cypher and code work, for which his unique knowledge and wide experience in cryptography so eminently fitted him. He had to raise and train the *personnel* of the cryptographic bureau and to organize its work. In addition to his normal work in the bureau he instructed various naval officers in cryptography.

At the same time he was also appointed Chairman of the Army Sanitary Committee. Sir Alfred Keogh, then Director-General of Medical Services at the War Office, writes, regarding Anderson's appointment: " When in 1914 I was recalled to the War Office to reassume the direction of Army Medical affairs the necessity for a central organization for co-ordination of effort in the domain of disease prevention was at once apparent. The extraordinary efforts

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which were subsequently made in the various theatres of war only emphasized this necessity. If ingenuity in improvisation of sanitary details was in the main the prevailing characteristic of the workers in the field, opposing principles of action were often discernible. The efforts of the various centres required correlation, newly acquired knowledge needed diffusion. The application of scientific discovery to disease prevention in war specially concerns the engineer officer and it was the recognition of this fact which made it a matter of concern that the President of the reformed *ad hoc* Sanitary Committee should be an officer of the Royal Engineers; an officer, not only possessed of special knowledge in his own sphere, but well acquainted with the factors concerned in the origin and dissemination of the diseases of armies. I succeeded in securing Brigadier-General Anderson for the post. It was one which required not only special knowledge but special qualities and the Army was fortunate that the duties appealed in a special degree to this officer. Astuteness, sagacity and power of discernment are qualities as essential to successful administration, as frankness and power of conciliation. All these qualities Sir Francis Anderson possessed in a remarkable degree. If he was tenacious of his own views, he was open to conviction, for he could always see the other point of view. This is not the time to set forth, even in the briefest manner, the services rendered by the admirable body over which Sir Francis Anderson presided, but when the work of the Committee is recorded, the share which he took in limiting the ravages of disease in the various campaigns of the Great War will be found to have been large. In a position of great difficulty he was eminently successful. His success was in great measure due to his personal qualities, for his was a lovable disposition."

In a letter to Lady Anderson Sir Alfred writes ;—

"I had the greatest admiration and respect for him, but in addition I owe him a deep debt of gratitude for, at a time of great personal anxiety, he was good enough to come to my aid to relieve me in one department of my work of a great anxiety and responsibility. I trusted to him so completely that I never had the least anxiety after he took over the committee which under him did so great a work which only the initiated could fully appreciate. He was a truly good and great public servant."

In another letter the following occurs :—

"I am so conscious of your husband's great services to the State. . . ."

Sir Frederick Treves, writing to Lady Anderson, says :—

"General Anderson had an extraordinary knowledge of his profession in all its technical details. He had a very receptive mind and was always anxious to get hold of new ideas. He was most liberal in his views and most indulgent to the views of others. He made an excellent chairman, just, judicious, business-like and a

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model of courtesy. Outside his work he was the most genial companion possible, kind, considerate, unselfish. His humour was remarkable and as a conversationalist few could equal him. It was always a great pleasure, and indeed a great privilege to be associated with him in any 'mission'—or tour of inspection. His heart was in his work and what he did he did well. I should imagine that he had not an enemy in the world. Possibly one of his most marked characteristics was his quite astonishing ingenuity."

Sir Arthur Newsholme, a member of the committee, writes :—

"As a member of the Army Sanitary Committee I had, especially during the earlier period of the war, almost weekly opportunities of meeting General Anderson and of admiring and appreciating his courtesy to all his colleagues and to the many officers and men whom we met in our visits of inspection ; of realizing his resourcefulness in emergencies and the practical character of the advice he gave and his broadmindedness in giving due weight to medical as well as to the engineering considerations. It was on the due balancing of these two aspects of the subject that the success and results of the work of the Army Sanitary Committee depended, and of the importance and value and success of the work of that committee there can be no doubt. In the instances in which the counsel given by him as to the drainage arrangements, etc., of camps was not adopted, subsequent events showed that much financial loss had resulted therefrom. The stupendous task of securing elementary sanitation for the hundreds of thousands of men who were rapidly aggregating in immense camps was only rendered possible by active and continuous co-operation of military and civil authorities, and on the military side it was largely owing to General Anderson's work that this was rapidly and successfully accomplished. His colleagues will always remember with admiration General Anderson's exceptionally fine mental qualities and with gratitude his geniality and kindness and his helpfulness on every occasion."

The Star and Garter Committee of the British Red Cross on forming an expert committee to advise on the class of patient to occupy the Star and Garter Home at Richmond sought Anderson's help as a member of the committee. Anderson was a Fellow and also Vice-President of the Royal Sanitary Institute and a member of the Army Hygiene Advisory Committee.

He was continued in employment beyond the date of the Armistice, and only retired as lately as the 1st November, 1919, after nearly 42 years' service.

For his services in the War he was appointed a Companion of the Bath in January, 1917, and made a Knight Companion of the British Empire on the King's birthday, in 1919.

There is no doubt that the great strain of the War, coupled with the incessant travelling both in the United Kingdom and in France

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entailed by his duties on the Army Sanitary Committee, together with the grief at the loss of his gifted and beloved younger son, Major F. Sainthill Anderson, M.C., R.F.A., killed in action in France, in August, 1918, undermined even his strong constitution for with scarcely any warning he died suddenly of heart disease on the 6th March last. He was on the point of moving with his family to Ballydavid, Co. Waterford, a place which he had recently acquired with the intention of establishing his home in a neighbourhood he had known since childhood. His body was taken to Ballydavid House and he was buried at the Abbey Church of Waterford, the funeral being a military one.

Besides his great interest in cryptography he devoted much attention to mechanical aids to mathematical computations and produced a "Gunners' Slide Rule" for which he received the thanks of the Secretary of State for War. Anderson's patent Improved Slide Rule is also well-known. At the time of his death he had taken out a patent for an ingenious "Abacus," or circular calculating machine. This is a circular form of the slide rule.

Anderson was a keen Mason and was a member of the Waterford Lodge and when at Bangalore was elected Worshipful Master of Lodge United Service at that station.

Anderson's character was a peculiarly lovable one. He was the staunchest of friends and always ready to help lame dogs over stiles. Many must remember with thankfulness his generous help in time of trouble. His retentive memory and ready wit made him the best of good company. His activity of brain and body was exceptional and this activity he retained to the end. His death came as a surprise and shock to his many friends who grieve for the early passing away of one of the best of fellows.

W.H.

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REVIEW.

THE PROJECTION OF MAPS.*

The subject of map-projections has always been a thorny one, mainly because the writers who have investigated the theory have dwelt in different spheres from the map-makers who have had to make practical use of the projections. The two classes have possessed moreover no weights and measures in common: the mathematician estimates the value of a projection by means of different systems of errors; the map-maker's ideas of value are governed by such considerations as simplicity, economy, uniformity with his other projections, possibilities of future expansion, and the general utility of the finished map. It is at times a question whether to subordinate utility to mathematical accuracy or *vice versa*. The problem has been deemed worthy of study by some of the most eminent mathematicians of history, but the surveyors who work upon maps have neither the power nor the leisure to scrutinize theories. The co-operation of two different classes of men is thus required. The projection of maps may be likened to the erection of a column in architecture; the mathematical theory forms the base, the map forms the capital. The base by itself is useless, the capital is the architect's aim.

Although the subject of map-projection has been exhaustively dealt with by numerous writers, there are very few books that can be said to have successfully bridged the gap between the mathematician and the map-maker, between the base and the capital. Authors harass students with descriptions of numerous projections that have no practical use; they do not sufficiently explain the particular employment for which each of their many projections may be considered suitable; and they close their investigations before they have crossed the border-line between theory and practice.

The author of the book under review was Deputy Surveyor General of the Malay States, and the map-maker would expect to receive from him a helpful exposition. But Mr. Young is a skilled mathematician, and his book leans more to the mathematical side than to the practical. As an investigator Mr. Young deserves to rank with the eminent authorities of the past; his knowledge of theory is exceptional, and he is one of the few living authors who can be fairly regarded as experts. But his absorption in the scientific side of the problem, and his pleasure in grappling with mathematical difficulties have led him to curtail the practical side to such an extent that the professional map-maker will derive little advantage from his book. This is to be regretted; the map-maker is in want of a post-war exposition of useful and employable projections, and it would be difficult to find an author more qualified by experience to write one than Mr. Young.

Mr. Young has displayed much originality in his new treatment of the conical projections, but his descriptions of his own original steps are so

* *Some Investigations in the Theory of Map Projections*, by A. E. YOUNG; published by the Royal Geographical Society, 1920.

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abbreviated that he will not receive the credit he deserves. His plan of altering the scale error at the centre of the map in order to reduce the average scale error is the most valuable contribution that has been made to the subject for years.

Many surveyors have to work with rectangular co-ordinates and to consider the convergency of meridians: Mr. Young's references to these points are too brief. His new method of reducing the errors of the Cassini projection is useful and shows a grasp of the subject, but its novelty is not sufficiently emphasized.

An illustration of the want of unity between mathematicians and draughtsmen is to be seen in the conservative retention of Mercator's projection in modern atlases. Whilst the mathematician has been discussing the complexities of obscure projections, the draughtsman has continued to employ a projection which falsifies geography and which ought never to have been used for educational purposes.

The chief practical difficulty of the past has been due to the great number of projections, which have been thrust before the map-maker for his selection. He will therefore be astonished to learn from Mr. Young's book that the very best projection of the conical class was one invented in 1758 by the Rev. Patrick Murdoch and which has been subsequently forgotten. Whilst this projection possessing all the virtues has been allowed to sink into oblivion, many projections without any virtues at all have been continually brought to notice.

Another feature of Mr. Young's book will come as a surprise to map-makers. The latter class have always accepted the results presented to them by eminent mathematicians without question. But Mr. Young repeatedly points out mistakes in the mathematics of the highest authorities. According to Mr. Young (page 2) Sir George Airy "made a slip in his solution" and "Airy's erroneous tables have unfortunately been incorporated in later publications." Mr. Young also shows (page 4) that Clarke made an error in his calculations, and (page 72) that Jordan's formula was wrong, and (page 75) that even Helmert's formulæ for convergency were incorrect. Each of these mistakes may have been individually unimportant, but their cumulative effect is disconcerting. All these mathematicians were surrounded with computers, and their work could have been checked before it was published.

No discussion of map-projections is now complete unless it refers to the changes which the views of geographers have undergone since the end of the nineteenth century, when the Paris conference issued its recommendations for an International Map of the World. Old-established mapping offices were then led to look into the projections which they had inherited and which they had hitherto reverenced as the mystic symbols of ancient wisdom. Their examination showed that a want of understanding had separated the mathematicians and map-makers of the past. The utility of a map had too often been subordinated to mathematical difficulties. A geographer now realizes that he only requires three projections in order to make good maps of a whole continent; he requires one projection for his small-scale geographical maps, another for his topographical maps on all their various scales, and a third for his revenue surveyors who have to work with rectangular co-ordinates.

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The definite recommendation of the polyconic projection by the International Conference brought more light to mapping offices than the technical treatises had done. This projection is becoming widely adopted for maps on various scales. The advantages of having maps on the larger scales all fitting into the smaller are great ; projections are becoming unified, margins made coincident, overlaps eliminated. Co-operation in a map of the world is moreover teaching a surveyor to look beyond his own borders ; he can no longer give to his projections such final limits, as his predecessors were apt to do ; he must allow for possibilities of expansion.

Mr. Young discusses the " best " projection for a long narrow country like Italy ; by " best " he means the projection that will show a minimum error. But a question, that will occur to many map-makers, is whether any map of Italy will be found satisfactory if it excludes the Alps, the Adriatic and Sardinia ; if these areas are included, Italy can no longer be regarded as a narrow strip. Moreover the Italian Survey has already adopted the polyconic projection for its maps on the scale of 1/million, and this step may render the same projection convenient for other scales.

In discussing the " best " projection Mr. Young does not mention the scale of the map, which he is contemplating. The problem for the best projection of a given area is dependent to a certain extent upon the scale of the forthcoming map. One projection may suit a wall-map on a scale of thirty miles=one inch, and another projection may be more suitable for a large scale map (one mile=one inch) published in numerous sheets.

The conical projections, as they are generally understood by geographers, have their pole corresponding with the pole of the Earth, so that meridians of longitude are directed towards the pole of the projection. Dr. Hammer has suggested conical projections, in which the pole of the projection does not correspond with the Earth's pole. An artistic cartographer will dislike the mathematical conception of a cone placed askew on one side of a spheroid, and his objections will have Mr. Young's support. The latter writes that " when the pole has a skew position the map has an ugly appearance," and that the only " useful " position is when the pole corresponds with the Earth's pole. Hammer's idea is thus vetoed on practical grounds.

S. G. BURRARD.

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65 R.E.

A SHORT RECORD OF THE SERVICES OF THE 65TH FIELD CO., R.E. (Cambridge, W. Heffer and Sons, Ltd. 1920).

This is the record of the services of an R.E. Unit of the New Army, from its formation in 1914 to its demobilization in 1919. It served in Gallipoli, Salonica and Palestine, and was one of the R.E. Companies in the retreat from Serbia in 1915. The record is most instructive from the fact that it records the personal experiences of officers and men which will never appear in any official history, and gives an insight into the life and trials of the human units of an R.E. Coy. which is invaluable. The book is well illustrated by photographs, but it is a pity that there

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are no maps. A feature of the book is the list of names and addresses of old members of the Unit given in the appendix. The final page of the record shows the family feeling that existed in this and, I believe, all good R.E. Units. One of the photographs contains the picture of a fox terrier dog—Jumbo. Jumbo was a dog of large experience—he was picked up by the Headquarters of C.R.E. 27th Division at Mericourt on the Somme in September, 1915. He was then starving and attached himself to us. I can remember one day there was a scare of mad dogs in the area and the edict went forth that all dogs were to be destroyed. All dogs but Jumbo disappeared, though I imagine that camouflage, not execution, was the cause. Jumbo was *persona grata* at Divisional Headquarters and I remember that much amusement was caused by his being found in the Divisional Commander's private office some days after the edict for the execution of dogs had gone forth. Jumbo attached himself personally to Captain Noble, D.S.O., my adjutant, and followed him everywhere, even into the front trenches; one of his amusements being to jump over the parapet and to run about amongst the wire. Noble took him to Salonika when he went out and kept him with him everywhere. What happened to him ultimately I do not know, but I trust he is at peace wherever he is; he was a very nice dog.

G. WALKER, *Colonel.*

107TH FIELD COMPANY, R.E.

(Darlington, Wm. Dresser and Sons, 41, High Row. 1920).

The book under review is the second volume of these recollections. It has been compiled by the Editor, Captain M. J. Rattray, with a view to providing a souvenir for the late members of the Unit and their friends. The book is well illustrated with photographs and there are useful maps. The experiences of this Unit commenced on 25th November, 1914, when it was formed under the command of Captain Eustace, R.E. at Chatham. It went to France in the 26th Division in 1915. This Division was put into the 12th Corps and went to the line on the Somme in September, 1915. From thence it went to Salonika with the rest of the 12th Corps in November and December, 1915. The book gives a very good account of the Salonika campaign from the point of view of an R.E. Field Company, and further interest attaches to the account from the fact that the 107th was the only R.E. Company to cross the Danube and enter Roumania, after the collapse of the Bulgarians and Turks. The Company was disbanded in the Balkans when the 26th Division was broken up.

G. WALKER *Colonel.*

OLD EUROPE'S SUICIDE.

By BRIG.-GENERAL C. B. THOMSON. (George Allen and Unwin. 5/-).

This little book contains a clear and delightfully interesting account of recent history in the Balkans.

F.E.G.S.

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NOTICES OF MAGAZINES.

MILITÄR WOCHENBLATT.

No. 23.—*Study and Criticism of Military History.*—General Ludendorff contributes an article on the study and criticism of military history. He first of all points out the importance which has been rightly attributed to it in the German Army, and then proceeds to indicate the lines which should be followed.

Since human nature does not change, the study of all campaigns, however far distant in time or place, is of value, but for the purely technical military side, the most modern have a greater value than the older ones. Not only do the constant developments in armament and equipment make this the case, but strategical ideas are continually growing and must be kept pace with.

The study of the world war is a task that should be undertaken not only by soldiers, but by every German man and woman, so that the degree of political education reached by their enemies, which gave them the victory, may also be attained by Germans. He declares that only by this means can Germans cease to be an unpolitical nation of unpractical dreamers and acquire the will to power, so strongly developed in the tough and stiff Anglo-Saxon race.

He repeatedly emphasizes the need for strict and impartial accuracy in compiling history, but would have it combined with warm patriotic feelings. The examination of official records will, he regrets, be held up by all governments for many years, but he hopes that, meanwhile, all that is possible will be done to place on record accounts of events, obtained from those who actually directed or took part in them. While war diaries have a certain value, he does not think too much reliance should be placed on them, because there was so often not enough time to compile them properly. He admits that he never looked at the G.H.Q. diary, nor did he take any special steps to have his telephone conversations recorded.

Private diaries and the reports of returned prisoners of war must be studied and the scope of the history must be enlarged to include such subjects as the economic situation, the U-boat campaign, the relations between the Army and the people, and the effects of propaganda; but above all he demands searching examination as to the truth of all state ments, so that legends, many of which have been purposely circulated, may be eliminated, and accuracy, which is the foundation for all useful criticism, unfailingly ensured.

The Marne Campaign of 1914 is General von Kuhl's account. As chief of the General Staff of the 1st Army he has special knowledge of events and he recounts them clearly and well. He brings out particularly, how the Schlieffen plan of an overwhelmingly strong right flank was spoilt by those who tried to combine this with strength elsewhere, and thus fell

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between two stools. The 1st Army was too weak and G.H.Q. wished its weakness to be compensated for by mobility. The most important decision made by the 1st Army was that of the evening of the 2nd September, when it was determined to attack the flank of the French Army falling back in front of von Bulow, and when this decision was adhered to, in spite of the protests of G.H.Q. This movement undoubtedly lightened the task of Manoury and the British, although the 1st Army, by its quick move back to the Ourcq, got well out of a disadvantageous position without much loss. The reviewer thinks that the leading of the 1st Army in August and September was, on the whole, a first rate performance.

The Revolutionary Army.—The Communists have got as far as publishing a book entitled *The Revolutionary Army* wherein are laid down the principles to be followed in the Army which is to arise after the establishment of a communistic state. The organization of this Army is to follow that of the old Imperial force, but the recruit is to be taught his trade in from 1½ to 3 months, with short refreshing trainings in subsequent years. The leaders are to be drawn from *personnel* so trained, and not from any professional class of soldiers. The writer quite sees that such an army will probably have to give ground before its enemies in the first place, but finds definite advantage in this fact, by reason of the guerilla war which will spring up behind the backs of the invaders. The *M.W.B.* thinks that the invaded population would probably prefer the rule of their enemies to that of the Communists, and would wish that the author could go through the test of war with his precious army, were it not for the slaughter of his innocent followers that would be involved.

Cost of War Material.—Among other examples of prices in 1914 and 1920 are the following :—

	1914.	1920.
Rifle	50 marks.	800 marks.
Field gun	12,500 ,,	164,500 ,,
4.2 howitzer shell ...	50 ,,	865 ,,

In view of these the *M.W.B.* is no longer surprised at the Reichswehr estimates.

No. 24.—*Study and Criticism of Military History (continued).*—General Ludendorff concludes his remarks on military history. He warns the critic against trying to prove theories, but advises him to follow the causes of failure down to the last detail. If this brings him up against the reputation of any individual, he must proceed with caution, so as not to wound susceptibilities unnecessarily, but all the same he must face his facts, and no military leader should fear impartial and well considered examination of his actions. On the other hand one-sided and destructive criticism, based on prejudice, can only serve to undermine authority, and must be steadfastly avoided, especially in these days when so many bad influences are abroad. The words of the old training manual must be remembered, "Neglect and omission are more blameworthy than mistakes in choice of methods." The reader of criticism must also weigh up his author, to see whether he is

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really equal to his task, and not take all that he reads as infallible, merely because it is in print. Lastly General Ludendorff wishes to see the great deeds of the Army brought well to the front, so as to give its enemies no cause to rejoice in the downfall of that of which they still stand in fear.

No. 25.—*The Roumanian Campaign.*—The first volume of General von Falkenhayn's account of the Roumanian campaign is published. After mentioning the embarrassment which the hesitating attitude of Roumania caused the central powers, who wanted the country, both on account of its resources and for access to Turkey, he describes the formation of the 9th German Army, which was destined to free the invaded Hungarian territory. The battle of Hermannstadt is rated as a second Tannenberg, on a smaller scale. In both cases an encircling attack was conducted against one army, while a second, which if rightly handled would have brought the Germans to disaster, was successfully held off. The battle was full of very critical moments, as the 1st Austrian Army failed and Roumanian attacks threatened to crush the weak German left flank. In spite of all danger, von Falkenhayn pushed his plan through and in four days, from the 26th to the 29th September, disposed of the 1st Roumanian Army. The following days were, however, full of anxiety for the Germans, but Falkenhayn's determination never to be forced into the defensive, which he says he could never have successfully maintained with his numerically inferior forces, was justified. In 18 days his army advanced 200 kilometres, fought three battles, and beat two armies, in spite of almost impassable mountain tracks. Von Falkenhayn complains that G.H.Q. interfered in some cases, without proper knowledge of the situation, but it is admitted that on the whole the higher command gave him every assistance possible in view of the critical situation on the other fronts.

The Bavarian Heavy Artillery.—This, before mobilization, had a strength of only about 4,000 officers and men, and 500 horses. In the spring of 1918 the continual demands for heavy artillery brought these figures to 46,000 and 22,000 respectively. In killed alone, losses amounted to 234 officers and 4,600 other ranks. The *M.W.B.* states that the greatest testimony to its performances lies in the fact that the Allies have determined to abolish it.

Army Orders.—The way in which N.C.O.s and men can qualify for commissions is laid down. Selected candidates have first to pass a general knowledge examination, and next an officers' qualifying test. They will then be allowed to go, in October, 1921, to the School of Arms, where there are further obstacles to be overcome before they can get their commissions.

The 30.5 cm. Austrian Howitzers.—It is stated that neither these nor the 42 cm. German howitzers were the invention of the Skoda works. Their development was entirely due to a military technical committee.

Bridge Building in the English Army.—A short note extracted from a Swiss military quarterly review, is given on the Bridging School at Aire. It is stated that the activities of the R.E. in bridging were of a wide scope. In 1918 they built 1,200 bridges with a total length of 8,100 metres.

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In Battle Undefeated is the title of a book contributed to by all the famous German fighters, from Hindenburg to Richthofen. It is compiled in popular form, and, as its title indicates, is intended to raise the confidence of the German people.

No. 26.—*Increase of Pensions.*—The Reichstag has voted an increase in the pensions of all on the old scale. Present prices had placed the old pensioners in a very hard position and the increases which are quite substantial, will be welcomed. As the cost to the State is put at 500 million marks, it has been decided that income from other sources shall be taken into account, and a reduction in pension be made if a limit of total income is exceeded. With the exception of this clause and of one or two others, the *M.W.B.* approves of the measure which may therefore be considered as fairly generous. Some examples of pensions under the new scale are as follows :—

			Marks.
Lieutenant	with 10 years'	service	5,676
Captain	,, 25 ,,	,, ...	11,577
Major	,, 30 ,,	,, ...	15,328
Colonel	,, 40 ,,	,, ...	21,420
Maj.-Gen.	,, 40 ,,	,, ...	28,420
Lt.-Gen.	,, 40 ,,	,, ...	33,420
G.O.C. in C.	,, 40 ,,	,, ...	41,420

These figures include a bonus for high cost of living.

The Policy of the Entente Powers towards Russia.—The writer begins by stating that the Entente abandoned the Czar as soon as the danger of his concluding a separate peace arose, and goes on to say that, as soon as the war ended, divergencies in *Entente* policy began to appear. The one main point, on which all agreed, was that Bolshevism must not be allowed to spread. Views as to the best way to prevent it doing so are, however, so varied, that very little is actually effected. In France the main object is to save the 25 milliards advanced to the Czarist government. She must therefore always try to upset a government which repudiates this debt, and. to do so, has in turn supported Judenitch, Denikin, Petlura, and Wrangel. The only assailant of the Soviets whom France did not support was Bermondt, the reason being that he did not advance the second French object, namely to separate Germany and Russia as much as possible.

Poland was always sure of France's support because she fulfilled both her requirements. Even the senseless Polish attack on Kieff was lent every possible assistance on the off-chance that thereby the Bolsheviks might be brought down. August, 1920, was a time of danger to French interests ; Poland seemed on the point of collapse before the Red armies, and the only solution of the difficulty appeared to lie in the understanding with Russia, which England wished for. In such a case the 25 milliards were lost, hence redoubled support to Poland with, so far, successful results. But the future does not look bright. If only the Soviet government would recognise the pre-war debt, England and France could advance, side by side, but this the Bolsheviks will not do and England has little interest in pressing the point (!). If England concludes

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a trade agreement France will openly stand aside from it, but will encourage private trading, so as not to be out of the hunt for Russian custom altogether.

All the same she will always be on the watch for a chance to upset the Bolsheviks.

England's chief interest, as mistress of the seas, lies in keeping Russia shut off from them. Her other objects are, to have a share in exploiting Russia economically, and to keep Bolshevik ideas out of British Asiatic spheres of interest. British policy has been accused of inconsistency even more than French, but the accusation is only well founded as regards the methods with which it is pursued. Her support of Kolchak and Denikin was continued only so long as the plan of closing the seas to Russia was thereby forwarded. As soon as there seemed to be a prospect of a new Great Russia arising through the downfall of the Soviet government, British support lost its object. It became more advantageous to hold Bolshevik and anti-Bolshevik balanced against each other, since a united Russia would certainly seek re-union with the border states and thereby access to the sea. England therefore supports the border states, but cares no longer for shutting off Russia from the Black Sea, since, by the treaty of Sevres, she has the key of that outlet in her pocket.

As regards England's other two objectives, she hopes to make the opening of commercial relations with Russia conditional on the cessation of Bolshevik propaganda in Asia. As this condition appears likely to be fulfilled, and as the closure of the seas is satisfactorily assured, England may be said to have achieved her objects. Official recognition of the Soviet government is only a formality and of little importance.

America's attitude has been one of aloofness. She cares only for economic relations as soon as the Bolsheviks fall from power, an event which she thinks will soon take place.

Japan, like England, wants to keep Russia from the sea. She, therefore, favours the establishment of East Siberian buffer states, which shall be under her thumb. At the moment the Chita government is very Bolshevik, so Japan holds fast to the Pacific ports.

Italy wants commercial relations, but fear of Bolshevik infection, and of her allies, has so far prevented her from effecting them.

Russia fully appreciates the advantage she gains from the differences between the *Entente* powers and openly mocks their disjointed attempts to bring her government to the ground.

Attack and Counter Attack on Officers.—The Munich branch of the German Officers' Association has attacked the *Vorwarts* for speaking of the "contemptible corps of officers," and also Scheidemann for saying in the Reichstag "The officers have to thank the self-restraint of the men for the fact that on the 9th November, 1918, they lost no more than their epaulettes and badges." The *Vorwarts* replies to the attack by accusing the officers' corps of the murder of Liebknecht, Rosa Luxemburg and sailors, of the Kapp "putsch," of ill-treating their men, and of looting and atrocities.

L. CHENEVIX-TRENCH, *Major, R.E.*

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REVUE MILITAIRE GÉNÉRALE.

August, 1920.

Falkenhayn. The Breach and its Exploitation, by General Lavigne-Delville.—General von Falkenhayn in his book "*The German Supreme Command and its Essential Decisions* (1914-16)" gives interesting information on the problem of breaking the enemy's line, on the condition necessary for its accomplishment, and on its utilization by the strategic reserves, and primarily by the larger cavalry formations. Falkenhayn shows that the problem is solvable, was in fact solved on seven occasions during his tenure of command, but failed on six other occasions. It should be noted that the attack on Verdun is represented as undertaken only with the object of exhausting the French, and not with any design of effecting a breach, and he over and over again insists that on the Russian front the defeat of their armies, and destruction of their offensive capacity for the time being was all that was aimed at, and not the annihilation of their forces, as much owing to the inferior offensive capacities of the Austro-Hungarian army as to the Russian facility for slipping out of a trap. Falkenhayn shows that to effect a breach two conditions must obtain ; preponderating superiority, greater than was thought necessary before the war, in men and materials on the side of the attacker, and moral inferiority on the side of the attacked. In the cases of the seven successful breaches both these conditions held, in the six unsuccessful attempts one or other was absent. As regards these deductions it may be remarked that the enemy must stand to receive the attack. He might refuse the battle and withdraw to another position, but this procedure has limits. The Allies fell back in 1914 and saved themselves from envelopment, but at the price of abandoning the richest regions of France. On the other hand the Russians never hesitated to fall back, the immense size of their Empire allowed of it, but it is questionable whether that action did not sap the moral of the army and also of the whole nation, and the same remark holds good of the German retreat in 1918. A local retirement may be made on two conditions, that a strong position exists in rear, and that te ritory of little value is given up, but a general retirement would probably mean abandoning resources necessary for carrying on the war, and to retain these the last man must be sacrificed. It is to be hoped that in future France will have an army capable of carrying on a war from the outset on enemy territory, and not run the risk again of losing her fairest provinces. The breach once effected it remains to exploit it. The higher formations of infantry are assembled to widen the gap, and hold it open for the passage of the higher formations of cavalry. Not one of the breaches mentioned was exploited, and in each case the failure to reap the full fruits of the victory was due to lack of troops, but in some of the cases the possibility of such a success had not been anticipated. Two may be advantageously studied more closely, those effected by the Germans against the Russians at Tarnow in May and June, 1915, and at Lublin-Cholm on 16th July, 1915, both of them desired and prepared for by the German G.H.Q. In May a German and an Austrian Army were engaged (16 divisions infantry of which 7 were German). There was an Austrian cavalry division with each army. The breach made in the

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Russian lines extended for 160 kilometres, and the troops on each flank were badly shaken on a total front of 350 kilometres. Thus each division in the attack operated on a front of 10 kilometres, too extensive an extension, but deemed by Falkenhayn a sufficient density in view of the small value of the opposing force. The attack exhausted the infantry, and there were no fresh troops to push the advantage. Italy was about to enter the war, the attack halted, and the Russians formed a new defensive line. However the Germans determined to follow up their advantage although unable to count on strong help from Austria now occupied also on the Italian Front. Two infantry divisions from France, and two from Poland, were hastened over to Russia, a renewed attack in June was again successful, and Lemberg fell. In spite of a strong rumour of an Anglo-French offensive Falkenhayn determined to push on, but could send few reinforcements, and the force was now, owing to losses, inferior to that engaged in May and June. However, another cavalry division was added. He was not sanguine of continued success, and considered the country beyond the Bug unfavourable for further offensive operations. The Russian front was again broken on 16th July, and up to 9th August great results might have been expected, but again the attack was exhausted, and by 9th September the Russians reformed their line after a retreat of 300 kilometres in 35 days, and losing 650,000 men in prisoners. In consequence, Falkenhayn broke up Mackensen's command, distributed his troops to other fronts, and sent him to command against the Serbians. Why was the cavalry distributed between the two armies and not concentrated as a reserve, to exploit the breaches successively made? Mackensen does not seem to have realized the necessity for such a concentration, or was withheld by higher orders from arranging it, but that does not excuse Falkenhayn who was in supreme control of the war, and responsible for the distribution of troops on the various fronts. Again the group of armies of the East under Hindenberg comprised 39 divisions of infantry and 8½ cavalry divisions. All or part of the latter might apparently have been employed as exploitation troops either by Mackensen or Hindenberg. At the end of April Hindenberg's was the largest mass of cavalry which existed during the war on any front. His orders were to attack the north wing of the Russian Army, and by making a display of force along his whole front to mask the despatch of units to Galicia, and to organize an extensive cavalry raid behind the Russian front. The raid failed; based on the idea that the Russian dispositions had not been changed after the winter campaign in Mazuria, it encountered the Russian reserves in refused echelon behind their threatened flank. Cavalry could not attack unbeaten troops, and another reason given by Falkenhayn for the failure is that the cavalry advanced split up to such an extent that some fractions were mere patrols, too scattered for efficient unity of command. The cavalry retired, and formed a screen before an enemy little disposed to be aggressive, but as it was too late to employ them otherwise, they were left where they were, and Falkenhayn claims that they fulfilled the mission given to them. This is doubtful, at any rate they would have been employed to greater advantage in exploiting Mackensen's successes. It was possible to have transported them to

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Galicia in spite of Falkenhayn's assertion that the German railways on the East were insufficient for the execution of any lateral movements to any particular sector of the Russian front. The reason for the non-employment of the cavalry must be sought elsewhere, either in lack of influence of the supreme command over certain of their subordinates, or in a false conception of the uses of cavalry. The German high command had a remarkable grasp of the constitution, employment, and distribution of reserves, and its partition of them amongst the various fronts was masterly. There may have been a crisis of authority. Leaving aside difficulties with Austria-Hungary, mainly political, it was a question of the subordination of the German Army Commanders, and no doubt the victor of Tannenberg was not an accommodating subordinate. It is to him perhaps more than to others that Falkenhayn addresses an impersonal reproach accusing them of considering their own particular task the most important, and the troops allotted to them as their own property, and certainly on one occasion Falkenhayn had to invoke the Emperor's orders to induce Hindenberg to part with certain troops required by the supreme command for a general reserve. However this may be the German High Command seems to have misunderstood the services that cavalry can render. Of the three essential roles of the higher cavalry formations, reconnaisance, screening, and exploitation, a study of the war seems to show that the High Command was able in certain cases to dispense with the first, utilize the second, and did not believe in the third. (The arguments in favour of the first two deductions are not reproduced here as they do not bear on the subject). As regards the third, had von Moltke after the French defeat at Charleroi sent in pursuit a strong force of cavalry held in reserve for that purpose it may be said at the very least that the re-organization of the units would have been less easy and slower, that the sadly large losses in prisoners would have been far heavier, and that the stand would not have been on the Marne, but further south. Moreover if von Moltke had, instead of sending Marwitz in between the armies of von Kluck and von Bulow, employed his force in front of the IVth Corps operating from 4th September on Dammartin, Claye, and Lagny, he might at least have delayed the arrival of the French VIth Army, or rendered its action less energetic. Again on 21st March, 1918, when connection between the British and French lines was severed, the great question asked was "Have the Germans any cavalry?" By 27th it was known that they had none. Also on 27th May a German irruption crossed the Chemin des Dames, the Aisne, and the Vesle, a great gap was made in the French line, and hardly closed by hastening up cavalry reinforcements, but no German cavalry appeared to press the advantage, and their infantry advance gradually lost power. Had German cavalry been available it is questionable where the French lines would have been re-established. Thus Falkenhayn only followed the example of von Moltke, and preceded Hindenberg, in underestimating the third role of cavalry. It may therefore be concluded that this was the German doctrine. On the other hand, wherever the French anticipated making a breach, a reserve force of cavalry was always at hand to utilize it profitably, but unfortunately the opportunity did not occur. Which theory is correct is proved

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by the victory, but to this negative proof positive proofs may be added. On four occasions during the war operations have resulted in the final annihilation of an enemy, the two Serbian campaigns, and those in Roumania and Palestine. Of the first two full details are not available, but it may be noted that after the battle of Dobropolis the French cavalry carried out a pursuit towards Monastir, and one as far as Belgrade. In Roumania Mackensen constituted two corps of cavalry and after the battle of Targu-Jiu, in which he had hoped to effect a breach, he sent his cavalry into the plain to exploit the victory. Though hindered by the numerous water-courses of Wallachia this cavalry entered Bucharest on 5th December, having covered 400 kilometres in 18 days, taking numerous prisoners, and opening the way for the infantry. In Palestine in 1918 the battle on the front Jaffa-Jerusalem was undertaken to open the way for the British cavalry (accompanied by some French squadrons), who passed through a breach opened and kept open by the infantry. In two days these corps arrived at Naplus in rear of the enemy, in six more days had reached the Jordan, and three days later Damascus. The result was the capture of two Turkish armies with artillery and transport, and General Liman von Sanders only escaped owing to the speed of his motor-car, while his papers and part of his staff were captured. Judging from the one-sided evidence which alone is available to the public on the conduct of the late war it may be said that complete success is only obtainable when there is cavalry at hand to ensure it. Who knows that the fear of cavalry exploitation may not have had its influence in deciding the German Colossus to save his life by unconditional surrender. More fortunate than the French, the Italian cavalry was able at the end of their campaign to exploit completely the victory of Vittorio-Veneto. On 29th the Austro-Hungarian front was pierced in the centre, the Piave crossed, and the first exploitation unit reached Vittorio, 20 kilometres from the front, that evening. The breach having been widened and kept open, the cavalry corps of the Count of Turin (3 and soon 4 divisions) anticipated the enemy in his second position on the Livenza if he had wished to make a stand there, and even in the third, the Tagliamento, if he could bring his last reserves there. On 30th the cavalry corps crossed the Brenta, on 31st was at Sacile on the Livenza. On 3rd November it crossed the Tagliamento on a front of 40 kilometres. On 4th, collecting prisoners by the way, and even whole units of the staff, the Italian cavalry was in sight of the Isonzo, 50 kilometres from the Tagliamento. There was cavalry wherever it was required on a front of 100 kilometres, and no reorganization on the part of the enemy was possible. The armistice stayed further action. The writer here enters a plea for the maintenance of a strong force of cavalry in the French army of the future, and closes with an exhortation to his countrymen to face the cost of the insurance premium which is paid in the maintenance of an army, warning them that the expression *la revanche* once used with bated breath in France, is now openly spoken in Germany, and that the latter may be able to draw on the resources of Russia, in spite of the obstacle of Poland.

A. R. REYNOLDS.

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PROBLEMS

A CORRESPONDENT has sent the following extract from the *Morning Post* and enquires why the Problem is considered to be of such great importance :—

A series of nine public lectures on "Problems in Science" are being delivered at King's College on Wednesdays at five o'clock, and the first of these was given by Professor J. W. Nicholson yesterday on the subject of "Mathematics."

Dr. Nicholson said that it was not easy to make mathematics a simple subject to understand for the lay mind. Yet it was all-important, for it figured in all the three faculties of arts, science, and engineering. Many problems remained to be solved. The solution of one of them would gain a prize of £50,000 from the Academy of Science at Vienna. Briefly it might be explained as follows :—

If a larger number (N) is broken up into smaller numbers, find for all cases a proof for the formula

$$N = p^n + q^n + r^n + \ldots .$$

where p, q, r, etc., are different numbers, and "n" the same index for all the different numbers. About 100 solutions a year have been sent in regularly for the past 20 years, none of which have been right.

PROBLEM 14 (Colonel C. L. Young).

Each player plays once with and twice against each other player; devise an arrangement satisfying these conditions. How many such arrangements are there? The following games are given for 8 players, A, B, C, D, E, F, G, H :—A B *v.* G H; E F *v.* C D; A C *v.* B D; E G *v.* F H; A D *v.* E H; B C *v.* F G; A E *v.* C G; B F *v.* D H; A F *v.* B E; D G *v.* C H; A G *v.* D F; C E *v.* B H; A H *v.* C F; B G *v.* D E. Total, 14 games. How many other possible arrangements of partners are there under the above conditions?

PROBLEM 20 (Solution).

If the straight line $lx + my + n = 0$, meet the conic

$$ax^2 + 2hxy + by^2 + 2gx + 2fy + c = 0$$

in the points P and Q, find the equation of the pair of lines HP, HQ, the co-ords of H being $x'y'$.

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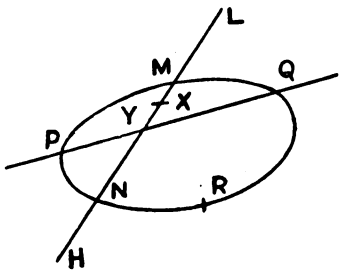

Co-ords of H are $x'y'$.

Let L be any point and $x''y''$ its co-ords. Consider any point X on HL and let the ratio $HX : XL = \lambda : \mu$.

Then co-ords of X are

$$\frac{\mu x' + \lambda x''}{\lambda + \mu} \qquad \frac{\mu y' + \lambda y''}{\lambda + \mu}.$$

Now if X is on the conic

$$ax^2 + \text{etc.} = 0.$$

The following equation must be satisfied :—

$$a(\lambda x'' + \mu x')^2 + 2h(\lambda x'' + \mu x')(\lambda y'' + \mu y') + \text{etc.} = 0$$

which is equivalent to

$$\lambda^2 S'' + 2\lambda\mu T + \mu^2 S' = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots (1).$$

Where $S'' \equiv ax''^2 + 2hx''y'' + by''^2 + 2gx'' + 2fy'' + c$

$S' = ax'^2 + 2hx'y' + \text{etc.}$

$T = x''(ax' + hy' + g) + y''(hx' + by' + f + gx' + fy' + c.$

Similarly if X be on $lx + my + u$, then

$$l(\lambda x'' + \mu x') + m(\lambda y'' + \mu y') + n(\lambda + \mu) = 0$$

must be satisfied, which is equivalent to

$$\lambda L'' + \mu L' = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots (2).$$

Where $L' = lx' + my' + n$

$L'' = lx'' + my'' + n.$

If then X coincide with either P or Q both equations 1 and 2 are satisfied.

If $\lambda : \mu$ be eliminated between 1 and 2 we get

$$L'^2 S'' + 2TL'L'' + L''^2 S' = 0 \quad \ldots\ldots\ldots\ldots (3).$$

Now equation 3 gives a relation between the co-ords of any point $x''y''$ on the lines HP, HQ and $x'y'$.

If then we write xy in place of $x''y''$ in 3 we get the equation of HP, HQ, which accordingly is

$$L'^2 S + 2TL'L + L^2 S' = 0.$$

Where

$S \equiv ax^2 + 2hxy + by^2 + 2gx + 2fy + c$

$L \equiv lx + my + n$

$T \equiv x(ax' + hy' + g) + y(hx' + by' + f) + gx' + fy' + c.$

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PROBLEM 23 (A. F. S. Hills, Esq.)

It is regretted that a mistake has been made in the statement of this problem. The following is correct :—

In the following long division sum all the figures, except those shown, have been replaced by crosses. The division is complete, *i.e.*, the divisor goes into the dividend without remainder. Show that there are four solutions.

```
× × ×)× × × × × × 4 (× 4 × ×
      × × ×
    ---------
      × × 4 ×
      × × × ×
    ---------
        × × × ×
          × 4 ×
        -------
          × × × 4
          × × × 4
          =======
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PROBLEM 24.

Correct solutions have been received from Lt.-Col. Allan J. C. Cunningham, Major C. R. Satterthwaite, O.B.E., Major P. G. H. Hogg, D.S.O , and Capt. F. Buero (Secretary, Academia de Ingenieros, Spanish Army).

New problems will be found in the SUPPLEMENT TO THE R.E. JOURNAL.

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REPORT ON THE EXPEDITION TO KAMET, 1920.

By MAJOR H. T. MORSHEAD, D.S.O., R.E. (*Survey of India.*)

THE mountain known in India as Kamet and to the Tibetans as Kangmed* or Abi Gamin—the 30th in order of magnitude of the known high peaks of Asia and of the world—is situated in latitude 30° 55′ and longitude 79° 36′ in the Garhwal district of the United Provinces just south of the Tibetan border. Rising to a height of 25,445 feet, it forms the culminating point of the Zaskar Range—a northern bifurcation of the Great Himalaya—and, though forming a conspicuous landmark from the Tibetan province of Ngari Kohrsum on the north, yet from the south, owing to its position behind the Great Himalayan Range, its appearance is so modest that till 1849 it remained unnoticed and unmeasured, though but 250 feet lower than the King of the Kumaon Himalaya, Nanda Devi.†

The earliest attempted ascent of Kamet was made in June, 1855, by the brothers A. and R. Schlagintweit who reached a height of 22,240 ft. on a mountain which they called Ibi Gamin, and believed to be identical with Kamet. Subsequent investigation has however tended to the belief that the mountain on which they actually climbed must have been the satellite known as E. Abi Gamin or Strachey's peak (24,180 ft.).

During the succeeding half century, the only recorded adventurers on the mountain were the members of the Great Trigonometrical Survey who triangulated and mapped the area in the years 1872-75. It was near here in the latter year that the late Mr. I. S. Pocock made what remains to this day one of the world's highest planetable fixings—setting up his board at 22,040 ft.‡

In recent times, numerous attempts have been made on the

* Kangmed = "the lower snows," as distinguished from the higher snows of the Kailas Range, culminating in Mt. Gurla Mandhata 100 miles to the E.S.E. The name has, I think erroneously, been spelled Kangmen in N. Frontier ¼in. Sheet No. 9 N.E. and on the R.G.S. map of Tibet.

† Burrard and Hayden, *A sketch of the Geography, etc., of the Himalaya mountains.* Kamet now shares the 30th place in the world's list of high peaks with Namcha Barfra, the mountain of identical height overlooking the big bend of the Tsangpo River in the Assam Himilaya, which was discovered during the Abor and Mishmi Expeditions of 1912-13.

‡ *General Report on the Operations of the G.T. Survey of India during* 1874-75. I have searched the original planetable sections of this area in vain in the hope of discovering the exact site of this fixing.

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mountain. The approaches both from the east and the west were reconnoitred in July and August, 1907, by Messrs. Bruce Longstaff and Mumm, but serious climbing was prevented by the onset of an unusually violent monsoon. C. F. Meade, accompanied by Alpine guides made three strenuous efforts to conquer the mountain, in 1910, 1912, and 1913. On the latter occasion, approaching *via* the Raikane Valley, he succeeded in reaching the col ("Meade's saddle," 23,500 ft.) between Kamet and E. Abi Gamin, when his party succumbed to mountain sickness just as success seemed within its grasp.

The late Capt. A. L. Slingsby twice attacked the mountain unsuccessfully from the western side, while Dr. A. M. Kellas, of Aberdeen, the well-known mountaineer, also reconnoitred the western approaches in 1911 and again in 1914—the expedition in the latter year, which had for its special object the scientific investigation of the effects of high altitude on the human body, being summarily cut short by the outbreak of war.

On the conclusion of peace the Royal Geographical Society, recognizing the desirability of collecting further data regarding the physiological effects of high altitude, persuaded Dr. Kellas to resume the experiments cut short in 1914. The Society also arranged for the loan of oxygen cylinders and other scientific apparatus from the Medical Research Committee in England, for its despatch to Bombay through the agency of the India Office Stores Department, and for the assistance of the Survey of India in taking delivery of the apparatus in Bombay and transporting it by rail and coolie, *via* Kathgodam, to the base of the mountain beyond the extreme Himalayan village of Niti. I was fortunate enough to be deputed for the latter task, together with Mr. Laltan Khan of the Survey of India Upper Subordinate Service.

The objects of the expedition may thus briefly be summarized :—

(1).—To study the physiological effects of high altitude on the human body, with special reference to the problem of acclimatization.

(2).—To obtain further information regarding the altitude to which ascent is possible without resort to artificial means of respiration, and to record the temperatures, wind velocities, etc., prevailing at extreme altitudes.

(3).—To experiment with the use of different forms of oxygen apparatus.

(4).—To make as complete a revision as possible of the 1″ to 1 mile reconnaissance survey of 1872-75 in the Kamet area.

The scientific observations contemplated by Dr. Kellas fall under five main heads, viz. :—

(1).—Comparative records at different altitudes of the pulse-rate respirations, lung-pressure, etc., of a number of selected subjects

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on similar lines to the tests for physical fitness devised by Col. Flack for use in the R.A.F.

(2).—Comparative measurements of the haemoglobin content of a measured quantity (20 c.mm.) of peripheral blood at different altitudes.

(3).—Microscopic estimation of the number of red corpuscles in a measured quantity (5 c.mm.) of peripheral blood at different altitudes.

(4).—Estimation of the amount of skin-evaporation by means of Hill's apparatus, known as the "kata-thermometer."

(5).—Analysis of the alveolar air (*i.e.*, air from the ultimate ramifications of the lungs) for oxygen and CO_2 content, by means of Haldane's apparatus for gas-analysis.

These observations, if commenced near the level of the plains at Kathgodam and continued as far as the highest point reached, might, it was hoped, yield valuable information regarding the rate and degree of acclimatization to altitude.

The oxygen apparatus, which was provided by the Oxygen Research branch of the Medical Research Committee, consisted of :—

(1).—Three sets of oxylith portable breathing apparatus manufactured by Messrs. Siebe Gorman and Co. ; these each consisted of a large rubber bag holding a sufficient supply of oxygen for 15 or 20 minutes consumption—the oxygen being generated on the spot by the chemical combination of oxylith and water.

(2).—60 steel cylinders of compressed oxygen, each weighing 15 lbs. when charged, and holding 280 litres of gas at 0° and 760 mm. Web belts and straps were provided for enabling these cylinders to be carried on the back, also a flow-meter for regulating the flow of gas to the face-mask at 1, 2, or 3 litres per minute as desired.

It was hoped that the apparatus might have arrived from England by the end of June, so as to enable Niti to be reached by easy stages on about 7th August. This would allow of the remainder of the month of August being devoted to laying out advanced depôts of oxygen cylinders, firewood, etc., as far forward as climatic conditions admitted, with a view to utilizing the first fine weather after the monsoon for the final climb, before the arrival of the winter snow. These plans were unfortunately frustrated by a very serious delay in the shipping of the oxygen cylinders—due, apparently, to the unexpected decision of the shipping authorities in England to classify the cargo as "high explosives." Consequently it was not until early August that the kit reached Kathgodam—whence, after hastily repacking the cylinders into loads suitable for coolie transport, the expedition started in pouring rain on 8th August.

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This unfortunate delay at the start involved the complete abandonment of Dr. Kellas' plans for comparative observations on acclimatization *en route*, and the paramount consideration now became that of pushing forward with all possible speed in the endeavour to reach the high ground before the onset of winter conditions; leaving the comparative observations for the return journey. Travelling *via* the rolling hills and fertile stuffy valleys of Kumaon, we reached Joshimath on 22nd August, and Niti five days later. Here we halted for a day to arrange for food supplies and for permanent coolies and yaks for our further progress.

Resuming our journey on 29th with a retinue of 24 yaks and 40 coolies, we encountered our first obstacle on the following day in the shape of the unfordable Dhauli River which separated us from the Raikane valley, at the confluence of the latter river. This necessitated a day's halt while the coolies constructed a cantilever bridge, the timbers for which came from the tree-zone below Niti.

The foot of the Raikane glacier was reached on 1st September. Dwarf juniper scrub (*bhitaru*) grows plentifully in this neighbourhood and forms an excellent fuel, which can be pulled up by hand by the roots without the use of an axe, and burns with a pleasant aromatic odour. Above this point no further fuel occurs, nor is the valley passable for yaks. We accordingly made this our base camp (15,380 ft.) and determined on a brief halt, in which survey operations and scientific observations could be carried on, while the coolies collected a reserve of fuel for our needs on the mountain. The yaks meantime returned to Niti for fresh supplies of provisions.

Marmots abound in the Raikane valley, and some excitement was caused on our first arrival at the base camp by one of my khalasis catching a tailless " mouse-hare " in his hat. The alpine flowers on the hillsides made a striking and memorable display in their brief autumn glory,—edelweiss, fleshy-leaved saxifrages, blue cranesbill, yellow and orange ranunculus, and dwarf primula being among the commonest and most conspicuous.

The thermometer at this altitude usually registered 6 or 8 degrees of frost each night, while the morning spectacle of a powdering of fresh snow covering the hillsides down to 16,000 or 17,000 ft. served to remind us that winter was at hand, and that our sojourn on the higher slopes must perforce be brief.

From the Raikane base camp our route was identical with that of C. F. Meade in 1913, and led over the moraines and crevasses of the E. Kamet glacier for a distance of 10 miles. Frequent and terrific avalanches from the steep S. and W. faces of the valley are a feature of this portion of the route, and form a danger to incautious travellers; safe camping sites may be found however here and there on the opposite side of the valley. We were fortunate in having with us some of Meade's old coolies whose knowledge of previous camping grounds

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etc., proved invaluable, and I am glad to take this opportunity of acknowledging our indebtedness to his gallant pioneering. Profiting, however, by Meade's experiences of mountain sickness after a series of long and rapid marches, we decided on adopting a programme of short and easy stages with frequent days of halting for acclimatization, which latter incidentally enabled the coolies to return for further supplies of much-needed fuel and provisions. Advancing in this manner, on 10th September we reached a camping ground at 18,460 ft., beyond which the route leaves the main glacier and ascends a steep side-valley.

The only incident worthy of mention in this portion of the trip was the loss of two live sheep by slipping through the thin mantle of snow which concealed one of the numerous large crevasses of the glacier. Two-and-a-half days later we managed to lower a coolie by a rope 40 feet into the crevasse, whence he succeeded after half an hour's work with an ice-axe in releasing the two sheep, which were hauled to the surface—one alive, and one reduced to frozen mutton.

On 11th September we advanced a further two miles and pitched a light camp on rock at a height of 20,620 ft. The majority of the coolies showed signs of distress and complained of violent headaches on arrival at this altitude; we accordingly sent them back to the last camp, keeping only two as guides for the 600 ft. of rock climbing which lay ahead. After a day's halt for acclimatization we successfully reconnoitred the rock-face on 13th, finally emerging at the top on to a smooth dome of glassy ice up which we had time to cut 45 large steps before returning to camp—a delightful day of real mountaineering.

Next morning the thermometer recorded 28 degrees of frost, while the small patch of rock around our tents was white with freshly fallen snow. Both Kellas' and my own servants were at this period completely *hors de combat* from the effects of the cold, and we had the greatest difficulty in preparing ourselves any cooked food. The daily convoy of provisions and firewood ceased to function in the absence of responsible superintendence at the various posts on our line of communications, and this in turn re-acted on the spirits of our coolie guides who became extremely despondent regarding the prospects of any further progress at this late season of the year.

Our position was manifestly too precarious to warrant any further advance pending an overhaul of the line of communication, and this I accordingly undertook at once. Retracing my steps down the valley on 15th., I installed my own private servant who now showed signs of convalescence as commander of the Raikane base camp, with orders to institute a regular system of *chālāns* or invoices notifying the daily number of loads of fuel and stores despatched; Dr. Kellas' Lepcha servant took charge of the forwarding arrangements at No. 1 camp (16,914 ft.) and Mr. Laltan Khan at No. 2 (18,460 ft.).

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This accomplished, I rejoined Dr. Kellas at No. 3 camp on September 17th, and found that he had meanwhile got his two coolies to complete the 35 more ice-steps required to negotiate the difficult ice at the head of the rock-cliff. After waiting one day, to ensure the arrival of the minimum necessary reserves of supplies, we advanced with very light kit and pitched our small single-fly tent on snow at 22,000 ft. Owing to sickness the number of coolies was now reduced to eight, who subsequently had to descend again for the night to camp No. 3, returning next day with a second tent (for themselves) and a small supply of ready-cooked food. It was impossible to get firewood carried up the difficult rock-face which separated us from the camp below; both we and our coolies were dependent on food sent up ready cooked from below, aided by such cooking as could be done by a spirit stove in the shelter of the tent. The thermometer next morning registered a minimum night temperature 15° below zero (47° of frost) on the surface of the snow, and our blankets were as stiff as boards where one's breath had congealed on them. Rising from our beds on the snow was consequently more than the work of a moment. However, after heating a tin of soup on the spirit stove and thawing sufficient snow to fill the thermos flask with bovril, we started forward at 9 a.m.—our two selves and three coolies being on the rope. Taking the lead in turns, and steering a winding course to avoid the giant crevasses, we gradually emerged on to the wide flat valley which separates Kamet from E. Abi Gamin. On our left the summit of Kamet showed clearly 2,000 ft. above us, connecting with the valley by means of two well-defined *arêtes* of easy slope, either of which must have been easily climbable had time permitted. It was now 3 p.m., however, and our coolies were dead beat, so after a brief halt for food and a round of photographs, we had to turn regretfully homewards from Meade's col, in order to avoid being benighted. The view from this col is magnificent—comprising the whole Tibetan portion of the Sutlej valley to the north, while 100 miles to the E.S.E. the stupendous *massif* of Gurla Mandhāta towered head and shoulders above the intervening army of lesser ranges.

Had we been able to induce the coolies to carry our camp one march further forward to the flat open *névé* near Meade's col, it is hard to believe that anything could have prevented our reaching the summit. Lack of properly cooked food, combined with the intense cold, had however undermined the stamina of the coolies, who absolutely refused to carry forward any further loads. My period of deputation had nearly expired, and realizing with regret that the season was now too far advanced for further efforts, I reluctantly bade good-bye to Dr. Kellas on September 22nd and turned my steps towards home, reaching Dehra Dun by double marches on October 15th—precisely two months from my date of departure. Dr. Kellas, with Mr. Laltan Khan, remained a further

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month in Garhwal, and succeeded in completing the essentials of his scientific work, which will form the subject of a separate report.

A few remarks may not be amiss in conclusion regarding the results of the expedition from the purely layman's point of view.

(*a*) *Physiological.*—The fact that neither Dr. Kellas nor myself suffered the slightest discomfort at any time from mountain sickness, seems to indicate that our method of attack by a process of gradual acclimatization is correct. That it is essential also to avoid undue fatigue is shown by the fact that our coolies who were carrying daily loads suffered considerable discomfort from the effects of altitude. The reasons for this it is beyond my province to discuss, I am merely concerned with observed results.

(*b*) *Mountaineering and practical.*—Under this heading, it may be profitable to discuss briefly the reasons of our failure to reach the summit of the mountain. Undoubtedly the first and foremost cause was the lateness in the year, due to the unfortunate and unforeseen delay in the arrival of the oxygen cylinders from England.

A second cause lay in the failure of the Survey khalasis recruited from the middle Himalayas to stand the climate and altitude of the higher ranges. I had enlisted a dozen strong Garhwali khalasis, with the double object of forming a *corpus vile* for the scientific observations of Dr. Kellas, and of providing a *corps d'élite* of porters for the higher altitudes. With the latter object in view they had been lavishly equipped with warm clothing on the "arctic" scale. Unfortunately, one half of their number succumbed to mountain sickness at 15,000 ft. while the other half proved so extravagant of our precious firewood that they had to be sent back to the base camp as "hewers of wood and drawers of water," and their places taken by the hardier "Bhotia" men of Niti and the neighbouring villages. The provision of boots and warm clothing for the latter on the spur of the moment was however a matter of difficulty, and proved a direct contributory cause of our failure.

A third cause of failure must be traced to the inadequacy of our arrangements for cooking at the higher altitudes. I was unaware until too late that the large Primus stove, on which I had been relying, would not work in the rarified atmosphere of 20,000 ft., beyond which point methylated spirit is the only possible fuel; while Dr. Kellas had only one small spirit stove which took an hour to thaw sufficient snow to fill a teapot. Had our equipment included a dozen large spirit stoves, and two or three 2-gallon petrol-cans full of methylated spirit, both our own and the coolies' cooking would have been assured.

I have nothing but praise for the Bhotia coolies of the higher Himalaya. On rock they can climb like goats, while on ice they readily learn step-cutting. It appears very doubtful if the present-day expense of importing Alpine guides can ever justify their employment in future Himalayan exploration.

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The following table shows the highest few climbs recorded :—

Duke of Abruzzi ...	1909	Karakoram	24,600
W. W. Graham ...	1886	Kabru	23,970 ?
W. H. Johnson ...	1865	Pk.i/61A	23,890 ?
Rubensen and Monrad Aas	1908	Kabru	23,800
C. F. Meade	1913	Kamet	23,500
A. M. Kellas and H. T. Morshead	1920	Ditto	23,500

Nos. 2 and 3 on the list are doubtful.

(*c*) *Oxygen apparatus*.—This will form the subject of a separate detailed report by Dr. Kellas. Neither of us felt the slightest need for artificial stimulants in the form either of oxygen or alcohol up to the highest point reached, and my impression is that one could have gone several thousand feet higher without distress of breathing, had other conditions admitted.

On the other hand the handicap of 15lbs. additional weight on one's back, supported by a system of tight belts and straps, proved more than I for one could cope with.

(*d*) *Surveys*.—I obtained a special blue print on drawing paper on the old 1″ = 1 mile Sheet No. 19. This was mounted on a light 20″ by 20″ planetable for Laltan Khan's use. 115 sq. miles of country were revised and contoured in modern style, disclosing considerable discrepancies in the old reconnaissance surveys. Roads, streams and watersheds were found sometimes as much as ¾ mile in error, while the original surveyors had evidently never visited the upper portions of the Raikane and Kamet glaciers.

It only remains to express my gratitude at being privileged to serve my apprenticeship in mountaineering under so experienced a hand as Dr. Kellas. Failure is often more instructive than success, and I can only hope that this expedition, on which I shall always look back with feelings of pleasure, may be the prelude to other more successful future efforts in the same genial company.

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Kamet and E. Abi Gamin—Camp 20,620′ in foreground.

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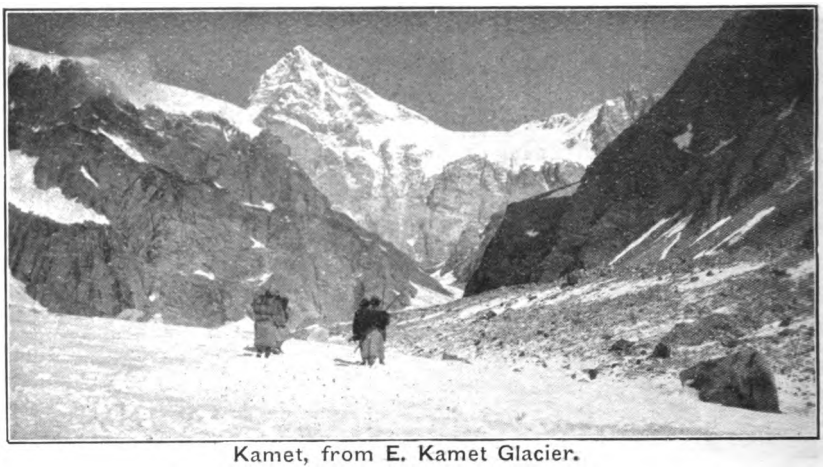
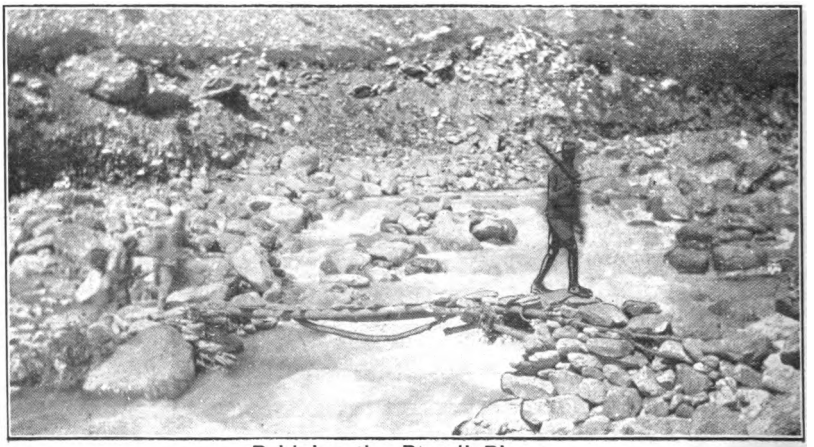


Kamet, from E. Kamet Glacier.

Rescuing sheep from crevasse on E. Kamet Glacier.



Bridging the Dhauli River.

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Bridging the Dhauli River.

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A SCIENCE OF INFANTRY TACTICS.

A lecture delivered at the S.M.E. on 6th Jan., 1921, *by* CAPTAIN B. H. LIDDELL HART., K.O.Y.L.I.

"SIMPLICITY is the key to victory." This vital truth has scarcely been fully valued in the tactical teaching of the infantry leader. Too many text-books on tactics dealt with war in a series of water-tight compartments, explaining the points of difference rather than the points of similarity. The junior Infantry Commander was taught many excellent precepts dealing with each phase of action, but his path was not smoothed for him by any framework of fundamental principles, upon which he could build as he acquired practical experience of ground and weapons. To simplify the task of the junior commander we require to establish the essential principles of tactics and their relation to the varying phases of battle. We must then fit them into their correct place, both in chronological and tactical sequence, in order to form a simple and truly scientific theory.

The family tree is an ancient institution and yet graphically clear as a chart of the various degrees of kinship. Let us endeavour to establish a simple and scientific tactical tree which will clearly convey to the military student the essential principles and their broad application to the phases of war. To understand these principles of tactics we must simplify and reduce it to the essential elements which are true of any fighting whether between two individual men, two platoons, or two armies. We will examine the simplest form of combat, that between two individuals. From their correct course of action, we can deduce the essential principles, and can then apply them to the conduct of war.

But it may be argued that the conditions of war are entirely different from those of a straightforward fight between two men; that in war the enemy's movements and location are hidden from us until we are actually at grips with him.

Certainly, we agree, but the situation in war will resemble that of two men fighting under similar conditions, such as in the dark wherein a man can only locate and reconnoitre his enemy by actually touching and feeling him. Thus the man in the dark resembles the commander in modern war. Let us examine the correct principles of action which a man seeking to attack an enemy in the dark would naturally adopt.

"THE MAN FIGHTING IN THE DARK."

I.—In the first place he must seek his enemy. Therefore the man stretches out one arm to grope for his enemy, keeping it supple and ready to guard himself from surprise.

This may be termed the principle of "protective formation."

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II.—When his outstretched arm touches his enemy, he would rapidly feel his way to a highly vulnerable spot such as the latter's throat.

This is the principle of "reconnaissance."

III.—The man will then seize his adversary firmly by the throat, holding him at arm's length so that the latter can neither strike back effectively, nor wriggle away to avoid or parry the decisive blow.

This is the principle of "fixing."

IV.—Then while his enemy's whole attention is absorbed by the menacing hand at his throat, with his other fist the man strikes his opponent from an unexpected direction in an unguarded spot, delivering out of the dark a decisive knock-out blow.

This is the principle of "decisive manœuvre."

V.—Before his enemy can recover the man instantly follows up his advantage by taking steps to render him finally powerless.

This is the principle of full and immediate "exploitation" of success.

To follow these principles is the only sure path to victory. We can only neglect the fixing phase, if our enemy commits some mistake, such as the neglect of his own security, by which he fixes himself without our intervention and so exposes himself to our decisive blow.

Now the whole action of our man-in-the-dark can be simplified into two categories :—

Guarding and Hitting.—The man guards against two dangers. Firstly that of personal injury from the enemy's blows; secondly that the enemy may avoid his knock-out blow and thus cause him to overbalance. The man guards against these two dangers by extending one arm in front of him ready to parry and take the sting out of the blow aimed at his body; by using this arm to grope for and feel the enemy; and finally when he has located the enemy by seizing the enemy so firmly at a spot (the throat) so vital that he will be forced to concentrate all his energy on its defence.

All these objects have a common object, and therefore may be grouped under one principle termed "security."

When the man has fixed his enemy, he delivers a decisive knock-out blow. It will be obvious that the harder this blow, the more likely it is to be decisive. Hence the man must put his maximum possible force into it, while he only uses the necessary minimum of strength to carry out the preparatory operations. This is the principle of "Economy of Force."

But the man can increase the effect of his available strength by surprising the enemy, by his speed, by the momentum or "follow through" behind his blows; by striking his opponent's most vulnerable spots; by full exploitation of every opening or advantage; by husbanding his energy; and by moving his limbs and muscles in

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harmony like the parts of a well oiled machine. All these are means to promote economy of force, and therefore can be grouped under that principle.

Thus we see that there are two, and only two, supreme governing principles—Security and Economy of Force. These two principles govern the execution of the five battle principles, and may be said to cut laterally across them.

A diagram may simplify the idea.

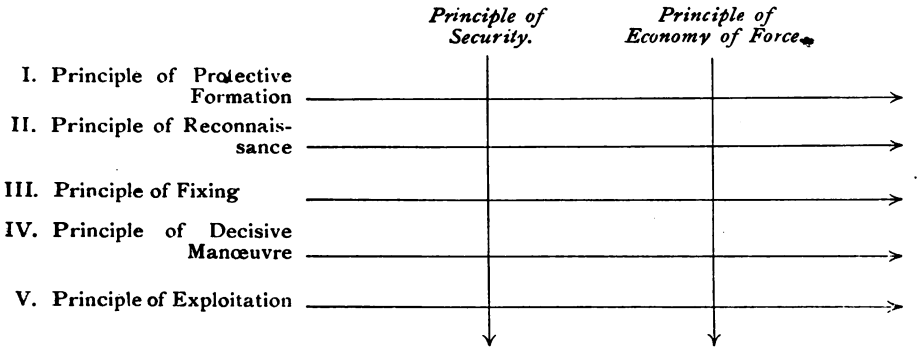
Principle of Security.
Principle of Economy of Force.
I. Principle of Protective Formation
II. Principle of Reconnaissance
III. Principle of Fixing
IV. Principle of Decisive Manœuvre
V. Principle of Exploitation

FIG. 1.

APPLICATION TO INFANTRY TACTICS OF THE TWO GOVERNING PRINCIPLES DEDUCED FROM THE "MAN FIGHTING IN THE DARK."

A. Security.—In war, as in individual combat there are two kinds of security:—Material and Tactical. The former is security against direct loss, such as casualties inflicted by the actual blows of the enemy; the latter is security against the indirect damage which we suffer if the enemy is able to avoid or parry our decisive blow, so that we weaken and expose ourselves to his counter-blow.

How does one obtain security? Exactly as did the man-in-the-dark. He pushed out one arm, which in war means adopting a **formation of security.** He used his outstretched arm to grope for and feel the enemy, which in war means **reconnaissance.** When the enemy is located, we **fix** him so firmly by an attack from one direction that he is unable to avoid or turn to meet our decisive attack delivered from another direction—usually a flank.

It will be seen that these three means to security correspond to the first three battle principles. Hence for convenience we will consider them in detail when we discuss the phase of preparation which comprises the three battle principles. The commander of any unit entrusted with the *rôle* of decisive manœuvre or exploitation must however remember that it is equally necessary for him to carry out these three "security" principles in the course of his own action.

B. Economy of Force.—Now let us consider the principle of economy of force as applied to Infantry. One must use the minimum strength for the phase of preparation, essential though it is. One

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must devote the maximum possible force to the decisive blow and its exploitation. In strategy or grand tactics the distribution of our available forces is a complex problem, but in infantry tactics it is comparatively simple. Each infantry commander, platoon, company, battalion or brigade, has only four fighting sub-units under his command, apart from certain auxiliary fire weapons such as machine guns or mortars.

Hence he has only three possible ways in which he can distribute them, and these are :—

i.—*One sub-unit forward for reconnaissance and fixing and three for decisive manœuvre.* This distribution will normally be best when advancing against an unlocated enemy as in the approach march or encounter attack. Thus he retains the bulk of his strength in hand until the position of the enemy has been discovered, so ensuring better results when the decisive manœuvre is carried out.

ii.—*Two sub-units forward and two for manœuvre.* This distribution will usually be advisable in a definite attack against an enemy whose positions have been located, in order to secure that the whole front of the enemy position in his sector is tested thoroughly so that a soft spot may be found. Moreover it is imperative that the forward body shall not be held up before it has firmly fixed the main resistance of the enemy, otherwise the manœuvre body may have to be used before the decisive moment —which would be the antithesis of economy of force.

iii.—*Three sub-units forward and one for manœuvre.* This distribution may be advisable when following a creeping barrage— which reduces the need or possibility of manœuvre. This will ensure that the whole frontage is cleared directly the barrage lifts and so enable the forward sub-units to keep close behind the barrage. Further reasons for this distribution are that in such a case the strongest opposition will probably come early, and that a counter-barrage is likely, in which event the bulk of the unit will escape it.

It may also be advisable to adopt this distribution when allotted an unusually broad frontage, in order to cover it with fire. It entails the risk, however, of limiting the force of your manœuvre.

It must be remembered that while the decisive attack is made by the maximum force, its success depends upon the enemy being really fixed. **Manœuvre is useless unless the enemy is first fixed in another direction.** Hence the manœuvre body is not necessarily the largest. The " last straw which breaks the camel's back " is a great truth in battle tactics.

It will be noticed that the author uses the words " forward body " and " manœuvre body," instead of the recognized terms " firing line "

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and " supports." This is because these terms are no longer applicable to modern infantry tactics. In order to instil a correct doctrine into the minds of the average officer and N.C.O. it is advisable to eschew misleading terms, and not to try to reconcile modern ideas with out-of-date phraseology.

The term " firing line " does not convey the idea of the outstretched arm or of distribution in depth. It suggests a broad frontal attack with no attempt to make use of covered ways of approach or to find the soft spots.

In the case of " supports " both the word and the idea are dangerous. It does not inculcate the essential idea of manœuvre, but rather the obsolete and unsound idea of reinforcing frontally troops who are held up, which means piling the dead in front of the enemy's strongest points.

Reinforcement of units which are held up causes confusion owing to the mixing of units, nor does it produce so great a moral effect as a diversion from a flank, either on the enemy or on the troops reinforced. As long as obsolete terms persist, there is a danger of a wrong idea lingering in the mind of the average leader. It is contended on the other hand that the terms " forward body " and " manœuvre body " instinctively suggest the true principles. *Even if we retain the old terms, however, the action of these respective bodies still holds good.*

When one speaks of weight or force in modern war it is essential to remember that it is weight of fire and not of mere numbers of men. An army composed of highly trained fire units capable of manœuvre can defeat far larger armies who rely on mere masses of men. Thus highly fortified enemy defences must be countered by an increase of mechanical fire power, and not by reducing the intervals, and so increasing the casualties, of the infantry.

The infantry commander must not however delude himself with the idea that he has fulfilled the principle of economy of force when he has correctly distibuted his sub-units.

He must use every means to increase the effect of his available numbers. How ? By following the same sub-principles as did the man in the dark, which were :—

i.—**Surprise.** Striking the enemy from an unexpected direction, at an unexpected moment, in an unguarded spot. It is the duty of every commander before and during the attack to use instinctively this, and the following, means to economy of force. He should ask himself subconsciously at every stage of the fight :—*How can I surprise the enemy ? Is there a covered approach by which I can get closer to the enemy or round his flank ? Is the smoke or fire of other units or arms affording me a momentary chance to get forward or to assault the enemy ?*

ii.—**Speed** of movement, fire, and eye. Opportunities in battle are fleeting and must be constantly noticed and seized.

iii.—**Momentum.** *How can I keep up the pace of the advance ? Is this a suitable moment to use the expanding torrent system ?* We will discuss this matter later.

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iv.—**Soft Spot,** seeking and striking the enemy's weakest spots, instead of dashing out the lives of one's men in front of his strongest points.

Where does there appear to be a weak spot or where is the enemy beginning to give way ?

v.—**Husbanding** one's men by the aid of correct tactics and covered approaches instead of massed frontal attacks in line.

How can I get my men over that exposed stretch with the least loss ?

vi.—**Mutual support,** whether of brigades or sections, all working together like the muscles of the body or the members of a football team.

Can I help the units on my flanks to get forward by bringing cross-fire to bear on the enemy opposing them ?

vii.—**Exploitation** to the full of every advantage gained.

How can I best exploit the soft spot which I have found or the fire position which I have gained ?

Before going on to deal with the execution of the five battle principles, let us consider certain

NEW CHARACTERISTICS OF THE INFANTRY FIGHT.

Infantry tactics have been thrown into the melting pot by the realization, which has been forced upon us, that our former methods are inapplicable and wasteful of force under modern conditions. The outstanding change has been the realization that the weight, or force, of an attack does not increase in proportion to the numbers of men thrown in ; that progress can only be made by intelligent manœuvre of fire power.

Increasing numbers beyond a certain density adds nothing to the effectiveness of the attack or defence, but only results in greater casualties. Instead of dense lines of bayonet men in attack, or crowded position, in defence, one must use widely dispersed combat groups containing comparatively few men, but well equipped with fire and smoke weapons. These must be allowed ample frontage to manœuvre and find the enemy's soft spots. Thus the exact intervals will depend on whether the ground is open or close.

It is necessary at this point to remember that, in any large action, each of the infantry units will be restricted to a definite sector of the front. At first sight therefore. it will be confined to a purely frontal attack. But modern destructive weapons have enforced a wide dispersion of the combatants on the battlefield. This dispersion has rendered possible penetration by the fire units—the sections—between the enemy defence posts. It is the *rôle* of the section, platoon, and company commander in turn by exploiting this penetration to change their sector of the battle from a mere bludgeon fight into a manœuvre combat, thus fulfilling the principle of economy of force by striking " from an unexpected direction against an unguarded spot."

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INFANTRY IN ATTACK.

We now turn to consider the application of our man-in-the-dark theory to practical tactics. The ideal infantry battalion, company, or platoon, should resemble a human tank, comprising both offensive power and protective armour. Its offensive power rests in its arms and legs, or in other words its weapons and manœuvring power. The protective armour is represented by an open formation, such as a diamond or square, which prevents more than one of the sub-units being surprised by the enemy, and so affords time for the remainder to manœuvre to take the enemy in flank.

A. Preparation (Security).

"The man extends one arm to grope for, feel, and seize his enemy by the throat."

I. Protective Formation.

We deduce from our study of the man-in-the-dark that each unit should move with an advanced guard or forward body—the outstretched arm—pushed out in the probable direction of the enemy, whilst the main, or manœuvre body, follows in rear. The latter will thus be ready to manœuvre against any enemy which the forward body encounters, and by its mere presence will protect the flanks of the forward body. In modern war the defenders can only be definitely located bit by bit by actual attack. Hence the danger of a surprise counter-attack is ever present.

An open formation of security is therefore just as vital during the attack as during the approach.

a.—The Advance or Attack against an unlocated enemy.

Maxim i. The best formation for any body advancing against an unlocated enemy will usually be that of the diamond (see *Figs.* 2 and 3). Whichever point of the diamond encounters the enemy first has the duty of fixing him whilst the other three manœuvre to take the enemy in flank.

Maxim ii. Until a unit is committed to attack on a definite point its commander should move with his forward body in order best to direct the movements of his unit and keep in touch with the situation in front. The diamond, with its solitary leading point, facilitates this direction by the commander, and enables him to make the best use of any covered approaches.

Maxim iii. Hence it should also be used for all manœuvre bodies and units in rear until they are committed to a definite *rôle*.

Maxim iv. **Security is the first essential.** Hence each unit should move *by bounds*. In this method each body advances alternately, while the other is halted in a position from which it can cover with fire the moving body. The manœuvre body, in an advance, will only bound as far as a position in rear of the forward body, from which it can cover the next advance of the latter.

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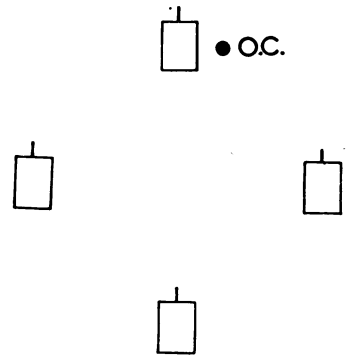

FIG. 2.—*Diamond Formation.*

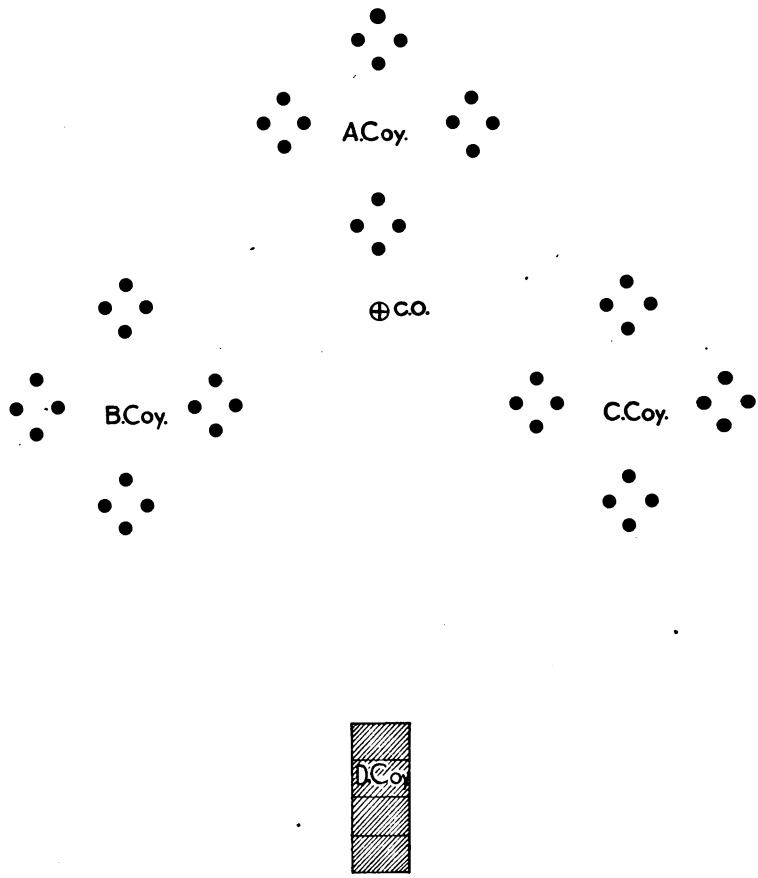

FIG. 3.—*A Battalion in the Approach March against unlocated Enemy.*

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When not in the neighbourhood of the enemy speed is more important than security. Therefore units should move in column of route along roads, with only the actual head of the forward body deployed. Thus in the case of a company serving as advanced guard or forward body to a battalion, only the forward platoon would be deployed in diamond formation, whilst the three manœuvre platoons move in fours along the road, until in the neighbourhood of the enemy.

b.—The attack against a located enemy.

Maxim i. You will normally have two sub-units forward and two for manœuvre. The formation will usually be a modified square (see *Fig.* 4). The two forward sub-units should be well apart in order to cover the whole extent of your frontage with fire and to thoroughly explore it for soft spots. The two manœuvre sub-units should move as close together as the enemy's fire allows, in order to be under quicker control for manœuvre.

Maxim ii. **Speed is the first essential,** and therefore continuous progress must be aimed at, instead of movement by bounds.

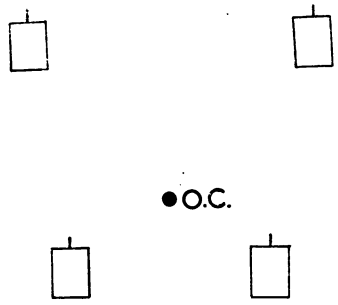

FIG. 4.—*Square Formation.*

SECTION FORMATIONS.

We now turn to consider the formation of the actual fire, or fighting, units which are the sections. The extended line is not a formation of security; it is not under the instant control and direction of the section commander and thus it prevents full advantage being taken of covered approaches and reduces the power of manœuvre.

The very idea of a line presupposes a wasteful frontal attack instead of a manœuvre combat. Hence it should be abandoned in favour of a formation such as arrowhead (see *Fig.* 5), with the section

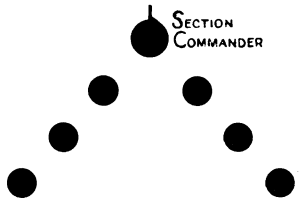

FIG. 5.—*Arrowhead Formation.*

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commander as the point of the arrow. Arrowhead is no more vulnerable to frontal fire than an extended line, whilst against enfilade fire it is even less vulnerable. It gives the section commander far greater powers of control and manœuvre, and is capable of firing in any direction. Thus it forms our ideal of a human tank or moving strong point.

When advancing through defiles or through woods and thick bush, the arrowhead can be closed in to form worm formation, in file or single file.

Maxim i. Arrowhead will therefore be the usual formation for both fire and movement.

Maxim ii. Worm will be the alternative formation for movement.

Maxim iii. During the advance the section commander must use his intelligence and change from one formation to the other as the ground dictates.

II.—RECONNAISSANCE.

Reconnaissance may be divided into two classes, "previous to battle" and "during battle."

a.—Previous Reconnaissance.

This is carried out by three methods :—

i.—The commander of each infantry unit studies all information regarding the enemy and the ground, which his superiors or the other arms such as cavalry and aircraft, have been able to obtain.

ii.—He carries out a personal survey of the ground ahead before committing his unit to an attack on a definite objective or to the defence of a definite position. In this survey he should be accompanied by his sub-unit commanders and any *liaison* officers.

iii.—Sending forward specially trained company scouts to carry out long distance reconnaissance to obtain information on definite points.

b.—Battle Reconnaissance.

This is carried out by observation and fighting :—

i.—Observation is achieved mainly by section scouts or patrols moving ahead of, but in touch with, the sections or higher units respectively which they are covering.

Maxim i. Each section when it has shaken out from the platoon should send a pair of scouts ahead to ensure protection. Section scouts should move ahead of, but within view of their sections. It is their *rôle* to discover the most covered ways of approach and to give warning of defence posts or parties of the enemy, and thus prevent the section coming under heavy surprise fire. They should move by bounds and at the end of each bound one scout should signal back for the section to come on or the reverse, whilst the other remains observing. When held up by the enemy's fire the section scouts should take up a position from which they can cover

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the section, as it moves up. The section should always move to rejoin its scouts in order that it may become an intact fighting organization once more.

Maxim ii. Patrols, which should consist of a complete section, or platoon, will be used to afford close protection to larger units. They should move in touch with the unit which they are covering, but considerably beyond the radius of action of the section scouts. Like larger units also they should move in a formation of security such as the diamond.

ii.—Reconnaissance by fighting will be carried out by the advance of the forward bodies which by actually attacking the enemy's position will feel and test it at all points, and so endeavour to discover or make a breach at some weak spot. Hence it may be best considered as part of the phase of fixing.

III.—Fixing.

Each forward body should advance direct on the enemy in order to reconnoitre him by fighting, discover and penetrate his weak spots and so continue its advance until it has gained the objective. If no soft spots can be found in the frontage allotted to it, it should fix him firmly, so that the manœuvre body can work round his flank and deliver a decisive surprise blow.

Maxim i. Thus when the fire of the enemy holds up a forward body, its duty will be to keep the enemy immediately opposing it **fixed** to his ground and to absorb his attention by maintaining a vigorous fire and working its way closer at every opportunity provided by the fire or smoke of neighbouring units or of the auxiliary arms.

Any slackening of pressure by the forward body will only result in the defence being able to turn and meet the flanking attack. There is a danger that during this flanking movement, the manœuvre body may be exposed to cross fire or counter attack from other enemy posts. This can only be averted by the neighbouring forward bodies really fixing their own immediate enemy. To ensure this mutual support every forward body must be determined to close with, and fix the whole attention of, the enemy opposed to them.

Maxim ii. The leading sections must not delay the advance by halting to fire until no further progress can be made without beating down the hostile fire.

Maxim iii. The action of the forward infantry in attack must consist of a constant pressing forward to close with the enemy in order to find the weak spots in his defences.

Maxim iv. To this end they must seize every available cover afforded by the ground, fire, or smoke.

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Maxim v. The speed of advance will be vastly quickened if tanks working with the infantry are used to carry the equipment and extra ammunition of the infantry.

Maxim vi. The forward sections can often fix the enemy defence posts opposed to them far more effectively by firing smoke to windward of them, than by rifle or Lewis gun fire. The smoke drifting down over the enemy blinds them and so enables the manœuvre sections to work round their flank unseen to assault them. Moreover this method economizes ammunition.

Maxim vii. To enable him to take instant advantage of any soft spots which are found by the forward companies or platoons, every battalion and company commander should detail an officer or specially selected N.C.O. with runners to move with each of the forward companies or platoons, and to send back word to him the instant a gap is found or made.

Maxim viii. Commanders should keep touch with the units on their flanks by observation or by sending out a patrol or special scout when the necessity for information or communication arises.

B (IV.)—DECISIVE MANŒUVRE.

"The man delivers a decisive blow from an unexpected direction against an unguarded spot."

Each manœuvre body will move close behind. Its normal purpose will be to assist, by means of manœuvre, the forward body to advance and gain the objective. If the fire of the enemy holds up the former body it will be the *rôle* of the manœuvre body to turn the flank of and enfilade, the enemy resistance which is opposing the forward body.

Maxim i. To achieve this a manœuvre body may have to quit its own sector and follow in the wake of a neighbouring unit which is still advancing. It will pass through the gap thus made, and come in on the flank of the enemy against which it will deliver an immediate blow.

As soon as this manœuvre has achieved its aim the forward and manœuvre bodies will mop up, reorganize and continue the advance until the objective has been gained. They will then consolidate the ground won in the most suitable tactical positions in the vicinity.

Maxim ii. If the enemy counter-attack during the advance the manœuvre body will be at hand and ready to counter-manœuvre against them.

Maxim iii. The commander of the unit must not however hold back or hesitate to throw in his manœuvre body to turn the enemy's flank directly it is clear that the forward body has fixed him.

Maxim iv. To guard against the danger of counter attack during its flanking movement. the manœuvre body must itself be distributed in depth.

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Maxim v. Company and platoon commanders should always move with their manœuvre platoons, or sections, directly they have committed their forward body to a definite attack.

Maxim vi. Battalion and brigade commanders should also move with their manœuvre companies, or battalions, but only until they commit them to a definite *rôle*. They should subsequently move with their reserve. Thus every infantry commander will be able to keep control of the course of the attack and influence it without delay at the decisive moments.

Maxim vii It must be clearly understood that the assault is not necessarily carried out by the manœuvre body. If the enemy turn to meet the latter, it will be the duty of the forward body to seize the opportunity to rush in and assault the enemy.

Maxim viii. In the case of the platoon the Lewis gun sections may often be used for manœuvre. They are less mobile and present a larger target than the rifle sections, but if covered approaches are available, they are more valuable for manœuvre, because of the greater surprise and enfilade effect of Lewis gun fire.

It is highly desirable that infantry should be systematically trained in deployment and changing direction *by signal.* These will not only be of great advantage during the approach march, but could be used on many occasions during the actual attack to quicken manœuvre and direct sub-units to take advantage of covered ways of approach. If thoroughly ingrained in the troops, signals can be used **at suitable moments** instead of the slower method of messages.

C (V.). Exploitation.

"The man instantly follows up his advantage and renders his enemy finally powerless."

a.—The limited or unlimited objective in attack?

In battle **the only true objective is the enemy**. But his actual strength and dispositions can only be ascertained by fighting. Hence certain topographical objectives must be allotted beforehand in order to serve as stepping stones by means of which the artillery can co-operate with and support the infantry advance. On the other hand it is a direct violation of economy of force to limit the advance of unexhausted units which find soft spots and can press on with little opposition. One should only replace those units whose momentum is checked by fatigue and severe opposition. Therefore these stepping stones—termed objectives—should be restricted to the battalion or higher formations. The companies, platoons, and sections of each battalion should press on to gain the battalion objective, their objective being the only true one—*the enemy*, wherever they find him in their path.

Hence the battalion will be the smallest unit which needs to carry out pursuit beyond the objective.

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b.—The Pursuit.

Companies and platoons need only be distributed into two bodies, forward and manœuvre, but battalions when carrying out a definite attack should be divided into three bodies: forward, manœuvre, and reserve. (See *Fig.* 6).

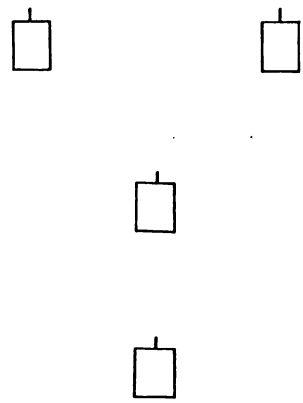

FIG. 6.—*Battalion in a Definite Attack.*

The reserve body is the means whereby the battalion or higher commander exploits success or retrieves failure. At the moment the battalion objective is taken, the enemy will be disorganized and probably demoralized, but if the attacking unit halts on the objective and is content to send out a few patrols only, the golden opportunity of exploiting the enemy's local reverse will be lost. If the troops which carried out the assault have to be reorganized for pursuit precious minutes will be lost. If a separate unit under a different commander is used for pursuit, delay is bound to occur, and the pressure on the enemy be relaxed, thus affording him a chance to recover.

Hence a fresh body, but one which is under the control of the commander who has taken the objective should be used for pursuit.

Maxim i. The normal purpose of the battalion reserve therefore will be to exploit the success and continue pursuit until such time as fast-moving tanks or other mobile troops have caught up and passed through them. In this way a relentless pressure on the yielding enemy will be maintained, so that his retreat may rapidly spread and gain momentum, thus resembling a snowball rolling downhill.

Maxim ii. If the forward and manœuvre companies fail to gain the objective, the battalion commander may use his reserve to relieve them or to meet counter attacks.

(*To be continued*).

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PROFESSIONAL NOTES.

THE WAR DEPARTMENT SCHEDULE OF BUILDING PRICES.

By COLONEL T. E. COLEMAN, O.B.E., *Chief Inspector of Works.*

PROBABLY every experienced Engineer and Contractor has some knowledge of this well known price book. For many years it has formed the basis for estimating the cost of War Department buildings and engineering works, and it is interesting to trace its development up to the present time.

So far as can be ascertained, the first War Department schedule was compiled about 1855. The earliest copy which can now be traced is dated 1865. It was divided into 10 trades, with 3,000 items and 7,000 prices. From time to time the schedule has undergone considerable expansion, but it is gratifying to find that the original arrangement for a series of building prices was based on sound lines, and this at a time when the measurement and pricing of building and engineering works had not been reduced to a uniform and standardized system. The general plan still remains on the same lines as in the original work.

Flattering evidence of the value of this book of building prices is afforded by the fact that other public departments practically adopted it as their model, adapting the various items to suit their own particular requirements. The Works schedules of the Admiralty, the Office of Works, the London School Board, and the London County Council, are all similar in arrangement and design to that of the War Department.

Further references to previous editions of the War Department schedule show that in 1874, it had increased to 6,000 items and 14,000 prices. In 1903, each sub-district had its own schedule of items and prices, with the result that there were 31 different War Department schedules then in use for the United Kingdom only. This involved a heavy expense in printing and revising so large a number of schedules, and keeping such a mass of matter permanently in type.

About 1908, an attempt was made to reduce the number of schedules, and also the number of items and prices. The number of schedules was accordingly reduced to nine. This comprised one for each of the eight Commands, and one for the Channel Islands. Another schedule was provided for Woolwich Arsenal, but this was prepared locally and not at the War Office. By a system of grouping,

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the items were diminished from 6,000 to 3,000, but still the number of different prices rose from 14,000 to 15,000.

In 1906 and 1911, a series of Addenda (one for each Command) was issued for use in making corrections and additions to the existing printed items and prices.

In 1914 the W.D. schedule was re-printed, the Addenda being embodied therein, but no other changes were made.

The present position, therefore, is that (including Woolwich) there are 10 different War Department schedules for building work used in the various Military districts of this country, each of which contain 3,000 items and 15,000 prices.

Even before 1914, it was realized that a thorough reconstruction and complete revision of the War Department schedule was a pressing necessity. In addition to the Addenda already mentioned, numerous corrections had been made from time to time, and in many cases new items had been interpolated without due consideration of the existing items and prices. Many discrepancies and inconsistencies therefore crept in. The introduction of new materials and new methods of construction had also not received sufficient consideration.

Then came the Great War, when all ideas of an improved schedule were perforce abandoned, but a few essential corrections were embodied in Addenda published in 1917. Now that the war is over, the necessity for a new schedule has become imperative. Compared with pre-war prices, all building values for labour and materials have been revolutionized. Roughly speaking, the cost of building is now about three times that of 1914.

The general principles laid down for the construction of the new schedule are as follows :—

(1).—The preparation of one standard schedule for the United Kingdom. Any modifications or variations in the local cost of labour and materials, as compared with the standard schedule prices, to be automatically adjusted by the Contractors themselves in their tenders, by adding to or deducting from the standard schedule prices the necessary contract percentage. Amongst other advantages, this proposal will reduce the number of schedules to be separately set up and printed, thus effecting a substantial economy in printing and stationery, whilst the work of future revisions will be simplified. It will also be possible to obtain a direct comparison as to the relative cost of similar works and repairs in all parts of the country. Another advantage is that Division Officers, Foremen of Works, and the Works Staff generally, having become accustomed to one standard schedule, will be in a position to take up their estimating and detailing duties in any part of the country on changes of Station, without having to get accustomed to a new arrangement of schedule items and prices. Detailed estimates made in one part of the country will be applicable

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to any other part of the country by an adjustment of the local Contract rate.

To meet the requirements of Woolwich Arsenal and of Scotland, (where certain special forms of building construction, or measurement, are sometimes required), it is proposed that a set of Addenda shall be prepared and attached to the standard schedule for use in these cases.

2.—The labour of measuring, squaring, abstracting, and moneying out the items of building work generally, to be reduced as far as possible. Many of the present schedule refinements (consisting of small variations in labour and workmanship) will be omitted. For instance, it is proposed that the prices for mouldings, etc., as fixed under average conditions will include the labour of forming mitres, instead of the latter being separately measured and billed. Prices at " per foot super " or " per foot run " will be adopted when practicable, in lieu of prices by weight. In the case of lead pipes, etc., convenient items, priced at per foot run instead of cwts., will be introduced. Under this arrangement, the work of reducing the measured quantities to weights will be avoided. To minimize clerical labour, farthings and halfpennies will be omitted, and round figure values substituted. Thus an analytical value of 7¼d. will be shown as a schedule price of 7d.; 11¾d. as 1s., etc.

3.—It is proposed to provide a complete series of items for " labour only " in order to meet the requirements of those stations where building materials are bought in bulk by the War Department, and direct labour is employed. By this means, it will be possible to prepare the necessary " labour only " estimates on a uniform basis of prices, as well as to obtain some recognized standard of comparison of cost in different parts of the country. This extension of measured labour values, will, however, involve a very large number of new items and prices being added to the schedule.

4.—The descriptions and items of workmanship, etc., to be simplified where practicable. The principle of using one combined item, instead of adding two or three together, will be extended. " Flat rates " for small items of general repairs will be introduced in order to save clerical labour in the preparation of incidental requisitions.

5.—Many items for materials and workmanship now obsolete, or rarely used, will be omitted. Other items and prices for new methods and materials will be provided. In this connection, the reinforced concrete section will be entirely remodelled and extended.

6.—A new section—the " Electrician "—will be introduced. These items and prices will embrace ordinary repairs to electric lighting, electric bells, etc.

7.—The specifications for materials and workmanship in each trade will receive careful consideration, so as to bring them into line

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with the best modern practice, and secure uniformity and standardization in all parts of the country. For this purpose the British standard specifications for cement, drain pipes, steel joists, wrought iron and steel tubes, pipes, etc., as laid down by the Engineering Standards Committee will be adopted as far as possible. A suggestion to introduce a decimal system of measurements and prices was carefully considered. Under present conditions, however, the practical difficulties were found to be too great to warrant its adoption.

8.—Taking the principal trades in their order, some of the salient modifications to be made in the new schedule are briefly mentioned :—

In the *Excavators' Work*, the items of excavating in various soils, etc., will be reduced. The measuring and pricing of trenches will also be simplified.

The *Concretor* section will be considerably extended, and, it is hoped, improved. Concrete is now a much more scientifically prepared material than in the old days when contractors apparently considered that any miscellaneous collection of gravel, brick, or stone *debris*, roughly broken, and containing a variable proportion of fine stuff, mixed with water, and a minimum quantity of inferior cement, might be dignified by the name of concrete. Such a material is far removed from the concrete which satisfies the requirements of the trained engineer of to-day. The proportions of coarse aggregate, fine aggregate, and cement, will be specified in detail. A number of items and prices for Reinforced Concrete will be introduced.

The *Drainlayer* section will be re-modelled, and additional items and prices for ' labour only ' provided for the use of stations where direct labour is employed.

For *Bricklayers' Work* it is proposed to adopt a mode of measurement more in accordance with the London Quantity Surveyors' practice. 'At present brickwork is measured in the War Department schedule at ' per foot cube ' and involves the squaring out of three dimensions for each measurement. The general practice is to measure and price brickwork on a superficial basis, except for heavy engineering works. In the latter case, brickwork in thick walls and large masses (as arches, dockwork, etc.), is measured by the yard cube.

For ordinary building works in London and the south of England, brickwork is almost universally measured at per rod of 272 feet superficial, reduced to a standard thickness of 1½ bricks. In the north of England, it is generally measured by the yard superficial reduced to the standard thickness of 1½ bricks, or else in accordance with the London standard rod of 272 feet super of reduced brickwork. Both the rod and the yard super units are, however, too large for adoption in a general repair schedule for small works. It is accordingly proposed to introduce a unit of 1 foot super of brickwork

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reduced to a standard thickness of 1½ bricks. The adoption of this principle will not only harmonize War Department measurements with the London and the northern practice of superficial measurements for brickwork, but it is also anticipated that Division Officers, Foremen of Works, and others will be saved considerable labour in squaring dimensions, etc.

Hollow walls will be measured net at per foot superficial of standard thickness, and a further item provided for forming cavity walls including the provision of bonding ties, etc., complete. This method is also similar to that adopted by London Quantity Surveyors.

In the general arrangement of the Carpenters' and Joiners' work, several alterations will be made. To facilitate reference, all items of carpentry—such as floors, roofs, etc.—will be grouped together in a more comprehensive form, and the Joiners' work similarly dealt with.

A suggestion that timbers, etc., in Carpenters' work should be reduced to a uniform thickness of 1 inch—instead of being calculated at per foot cube—has been considered. In the former case all timbers are reduced to a uniform thickness of 1 inch, and priced at per foot super of 1" standard thickness. This system is extensively adopted in Canada and the United States. Whilst the method may possess some advantages, yet on the whole they do not appear sufficient to justify a departure from the fixed practice amongst building surveyors, contractors, etc., in this country, of pricing such work at per foot cube.

The Slaters' and Tilers' work will be remodelled with a view to securing simplicity in measuring repairs, etc., to roofs. In the existing editions of the schedule, the items and prices for tiling are included with the Bricklayers' work, instead of in the Slating section, where they will be found in future.

Similarly, the items and prices for lime-whiting, colouring, etc., will be transferred from the "Plasterer" section to the "Painter and Decorator" section, where they properly belong.

As regards the remaining trades, no important modifications will be introduced beyond a thorough revision, consolidation, and grouping of the items and prices.

There are many difficulties to be overcome in preparing a standard schedule which shall apply generally to all parts of the country. The prices of materials and labour vary in some degree in each district. Its accomplishment will, however, be advantageous in many ways, as already mentioned. The ideal to be aimed at in providing a good standard schedule of prices for building works and repairs, is a price book in which contracts for London and large cities average about 10 per cent *above* the schedule prices, whilst contracts for Country districts average about 10 per cent. *below* the schedule prices. In other words, the schedule prices should

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represent the mean average cost of ordinary works and repairs throughout the various home military commands.

It will be seen that a re-construction of the War Department schedule in accordance with the broad principles laid down—including analysing and formulating thousands of prices to suit present conditions—necessarily involves an enormous amount of labour. The fact that at the present time, rates of labour, and prices for materials, are not yet stabilized, introduces further complications which are not present under normal conditions. These variations will, however, be corrected from time to time as they occur.

From one point of view, the preparation of a schedule which should provide for all building operations and for all variations of conditions and materials, is an absolute impossibility, the processes being so numerous, and the variations of the material factors, to say nothing of the human, being infinite.

A schedule of building values is therefore rendered practicable only by the adoption of average prices, and this must be remembered when criticizing or using them. It is quite likely that taking a particular piece of work, the schedule price may appear too high or too low, but it has been calculated with the idea of its being an average price over a series of jobs to be met with under that particular description in War Department work, and it is intended that both parties to the contract should interpret the schedule in that light.

It is hoped that Division Officers, Foremen of Works, and others who may be called upon to supervise, measure, and price building work executed by measurement contracts based on the new schedule will find it a somewhat easier task than at present.

It may be added that during the revision the opportunity will be taken of consulting experienced Division Officers and Foremen of Works, who are the persons most closely concerned with the application in practice of the book to estimating and billing, and who know where the shoe pinches most. It is hoped that their co-operation will be of the greatest value.

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THE ART OF TEACHING.

A lecture delivered at the S.M.E., Chatham, on the 27th January, 1921, *by* PROFESSOR FRANK J. ADKINS, M.A.

AN art is the expression of one's ideas and personality through some medium or other: hence there must be as many varieties as there are personalities; *i.e.*, art is individual and the rules of an art are therefore only observed uniformities, not imperatives. Moreover, an art is acquired not from talk but from practice under skilled supervision and from self criticism. All I can attempt therefore is to offer the result of nearly thirty years' teaching experience, in the hope that it may stimulate self criticism. If anything I say is taken as fixed, final, and absolute, I shall have failed in my object, which is not to prevent thought by the delivery of a sealed pattern system to be worked in its entirety, but to promote self criticism.

There will be many platitudes in this paper, but I do not apologize for them, since Truth is none the less true for being well-worn; and, as we shall see presently, the most hopeful of educational methods is the re-discovery by the student for himself of truths already known to the initiated.

My first platitude, then, will be this: Be sure you know your subject before you venture to teach it; and by knowing a subject I mean more than appears on the surface. For practical purposes a man may know his subject in a perfectly inarticulate way. His knowledge enables him to *act* correctly, but there it stops. But the teacher's knowledge must be articulate; he must be able to express it in words, and to this end he must reach the *rationale* of his subject, using the word Why? as the probe in his exploration of its foundations. Frequently I have found that people who have a difficulty in expressing themselves are by no means deficient in the power of expression; but they have no clear ideas as to the thing they want to express.

Understand a subject and the words to make it clear to others are most likely to come.

The second point about a teacher's knowledge must be its flexibility. It must be part of himself, completely under control, not merely a track traced through text books from which one fears to depart. One does not get one's flying certificate until one can perform all

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manner of stunts: one cannot ride till one can take one's own line across country and enjoy jumps.

Lastly, a teacher's knowledge must be question-proof; and question-proof in this sense. He need not necessarily have every detail in his text books in mind, but he must be so master of his subject that any question from a pupil, put, perhaps, in the course of a lesson, which suggests a different angle of vision or a new line of argument, is seized upon by the teacher as a means of a fresh handling of the subject, not dreaded by him as an obstruction threatening derailment.

So much for the teacher's knowledge. Now, what is the first step in preparing this knowledge for teaching purposes?

In the first place we need to arrange that the essentials are all dealt with in the time at our disposal. To find oneself only half way through one's subject at the end of one's period is obviously to have failed as a teacher. Secondly, we need to arrange our facts in such a way that they are all linked and woven together; none left isolated and alone, as unsupported "points to be remembered," but all braced and held together in a chain of continuing cause and effect, each fact arising out of a previous fact and leading on to another. Facts so marshalled become significant—more than Memoranda—links, rather, in a chain of argument; and students who have grasped facts thus, who have realized that they are the points which give the curve its direction, will remember them because they have digested them with the pepsin of the intelligence and so made them part of the brain structure itself; whereas facts obtained by a process of merely mechanical repetition remain alien bodies in the mind, liable to drop out in course of time. A further reward of this organizing of facts is that the structure so built up will bear a greater weight of detail than a loosely put together scheme.

Having finished our general preparation, we come now to the question of the detailed preparation of the various sections, lectures or lessons. In other words, we come to the vital question of the teacher's notes. Now, notes are a nuisance, because they come as a sort of paper barrage between the teacher and his objective. The teacher ought to have his eye fixed continuously on the class. Every time he looks at his notes he drops a certain amount of control and power to stimulate. If he reads his lecture from a manuscript he might as well have it printed and handed round in pamphlet form. What sort of notes then at once avoid these defects and help the teacher? Obviously not notes on subject matter, since by hypothesis the teacher is thoroughly master of his subject; but notes rather which enable him to handle his masses of knowledge effectively. To get lost in the tangles of one's own knowledge is no uncommon experience of the teacher, and his notes should be the

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guide-posts which enable him to keep to the path he has mapped out or to get back to it if for any reason he has strayed.

Notes then must be brief; and if their brevity is such that at intervals during the lesson they can be written up on a blackboard, they form, as a blackboard summary, the backbone of the whole subject. Nay, more, the key to the whole teaching position.

Our preparations are now complete and we are ready for the attack. (I am purposely leaving aside the preparation of experiments, illustrations, examples, extracts from books and so forth, although success in teaching depends largely on attention to such details, as it depends also upon skill in using the blackboard).

What is the weapon the teacher uses most in the actual conflict? Eye and manner of course to a great extent, but voice most of all. And so we come to the important question of language. Now, a man's language is his own, no two people express themselves in exactly the same way. Nevertheless certain general considerations arise. And here I shall have to distinguish between the lecturer and the teacher. Lecturing is a one-man show. The lecturer does the work and the audience does the rest—sometimes a very real rest too. Between him and his hearers there is a great gulf fixed. But the teacher's case is very different. His business is emphatically not to do the work and save his class the trouble. Quite the reverse. His success as a teacher is to be measured by the amount of work he gets out of his class; by the amount of mental energy he can develop among his pupils. He must make them teach themselves; and his language is his instrument. Let him then speak easily and colloquially, not slangily, ungrammatically or provincially, but chattily and informally, as one does in fireside talk. Let him speak also simply; always remembering that what may be simple to him may not be by any means simple to his class. A schoolmaster once began a lesson on King John thus: "The darkest passage in the reign of King John was the murder of Arthur," which one of the boys rendered thus, "King John murdered Prince Arthur in a dark passage in the rain." Which innocent little story brings me to the subject of jokes and laughter—perhaps the most effective ally the teacher has.

When a joke is made—or rather, when it is seen—a flood of energy is liberated and has to be worked off somehow. Now Nature's recoil mechanism is laughter, tears, and violent limb wagging in the excessively young. But all the energy is not thus taken up. What happens to the equivalent of the energy which propels the shell; the useful energy in a gun explosion? That flushes and refreshes the brain and nerve centres and so helps on our work like a shower upon a thirsty land. But obviously the jokes we need are only those which underline and emphasize our subject—a joke dragged in for the sake of the explosion is an impertinence, it does not belong

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to the scheme—we need those also which promote the thoughtful chuckle rather than the loud laugh which speaks the vacant mind. Nor must our jokes be too frequent. The outline of our subject must never be blurred by too great a flood of laughter. And lastly, our jokes must be properly constructed. A misfire is always a tragedy, and if there is any doubt as to the exact wording of a joke, I should not hesitate about writing down the joke in full in my lecture notes (but I should not copy those words on to the blackboard). Thus prepared and armed, the teacher moves towards his objective, the development of mental power among his pupils. And the dumbells of the mind which he has at his disposal are the facts of his subject, facts to be used obviously not as points to be remembered but rather as questions to be answered, problems to be solved, matters to be discovered. Let the student be placed in the position of those who were the first to find out the next truth in the subject, re-discovery of this sort (the Henristic method) is the natural process of education, and the truth found out in this way is sure to be remembered because the mental energy developed in the discovering of it has already assimilated it with the rest of the brain. Thus the teacher aims primarily at mental activity; but since that has to be exercised on a given subject, the reward his pupils reap is not only increased mental fitness, but also a valuable residuum of intelligently acquired and therefore applicable knowledge.

Nevertheless the knowledge is essentially nothing but the by-product, however vital and valuable, of the gymnastic process which is the teacher's real concern. The process may seem—and is—slow at first, but it is subject to acceleration and in any case the teacher should delay giving his help as long as he can. "The child's extremity is the teacher's opportunity:" a very sound old maxim provided one is quite clear as to which extremity the saying applies.

In this work the teacher is obviously only the leader of a group. Progress is the result of team work and the effectiveness of the team work will depend largely on the extent to which the teacher can, by manner, language and so forth, indicate that he is only *primus inter pares*, a captain in the games sense of the word. Indeed, if a member of the class happens to know more about a given section than the teacher, it is his obvious duty to carry on for the public benefit and for the teacher to leave him to do so. Thus frequently also the best brains in a group get the opportunities for exercise to which they are entitled, but which they are denied if the subject is taken by the teacher as a series of explanations suited to the dullest, a fatal form of waste, too prevalent in many educational circles. The student also who feels moved to ask a question in the course of the lesson finds himself encouraged to do so, because he, too, is helping on the joint effort towards discovery; whereas frequently the interrupter

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finds himself snubbed and subdued (if not ejected) in classes where teaching is a monologue by the teacher.

And so the lesson proceeds by a process of give and take—dialogue, question and answer, co-operation; and at the end there ought not to be any real need for the formula, "Any questions?" Nevertheless that formula may bring forth an odd question or two, and, if so, how can these also best be used for still further developing the mental powers of the class? Obviously not by the teacher answering the question; but rather by the teacher turning it back upon the class, a sort of mental ju-jitsu. If different members of the class have differing answers to the question which the teacher has repeated to them then, maybe, a division is caused in its ranks and each faction, to prove itself right, marshals all its facts and powers of argument against the other side. A debate thus started represents a maximum of mental energy and should be welcomed by the teacher.

Thus the lesson ends, but there are still one or two points deserving of a word or two. First: recapitulation. If I am right in my main thesis that, understanding once secured, the knowledge so obtained is registered automatically in the memory, then aids to memory like recapitulation and note taking become relatively unimportant. Nevertheless one aspect of recapitulation is worth a few words, not that by the teacher at the end of the lesson, but that by the class at the beginning of the next to consolidate. If each student has a paper and pencil and the teacher has his last lesson boiled down into a list of twenty or so questions, he can read out the questions one at a time. Each student writes the answer and so covers the whole ground in less than five minutes, each student having tested and corrected his own knowledge from the teacher's answers given at the end of the test.

Note taking is a more complex business because it results in a division of energy between listening and writing which is often fatal to both. Never measure the success of your teaching by the amount of note taking among your students. Some can make notes, of course and those may as well; but many are better employed in just following and understanding. Never go so slowly that your every word can be taken down and your lessons become merely dictation exercises. There are few mental jerks about dictation. If while you are putting your summary on the blackboard your students are copying it into their notebooks, no division of energy results; and if their notebooks contain ample blank space for the recording of their own reading, experience and thought in amplification of your lecture blackboard skeleton, you will find the notebook to be the key of the whole position. Its blackboard skeleton has not only kept you straight in your course, but it also connects you with your

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pupil's own efforts. His use of the blank pages reveals his character and progress to you: and the notebook itself is small enough to carry about yet elastic enough to add to throughout the rest of the student's connexion with the subject. If, in addition, you can give him during the first days of the course some idea of reading his text books pencil in hand, for underlining, marginal comments, cross references and the like, you will have done a great deal in helping him towards a successful career.

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"THE BRITISH SOLDIER AND THE EMPIRE."

By COLONEL B. R. WARD, C.M.G.

THIS pamphlet,* published for the British Academy, is a report of the Raleigh Lecture on History delivered by Mr. Fortescue on the 27th October, 1920. The Annual Lecture was founded by Sir Charles C. Wakefield, Bart., on the occasion of the Raleigh Tercentenary, October 29th, 1918. No living man is a greater authority on the British Army than the brilliant historian who has recently placed all soldiers in his debt by adding two more volumes to the greatest work on the deeds of the Army that has appeared since Sir William Napier's "History of the Peninsular War" was published in 1828.

In a pamphlet of 23 pages Mr. Fortescue here gives us his considered opinion as to the *rôle* and influence in the development of the Empire of the British soldier from the days of Queen Elizabeth to those of the Mediterranean Expeditionary Force and the occupation of Salonica. Taking Sir Walter Raleigh as his point of departure, he says that, although of course Raleigh was a soldier, it is not primarily as a soldier that we think of him at all. "We know him better," he says, "as a seer of great visions, a thinker of great thoughts, and a projector, in actual practice, of great enterprises for the widening of his country's power and influence." Not only so, but we think of him also as a poet and man of letters. "Here," he goes on to say, "is a soldier of whom surely it can be said that his sound has gone out into all lands and his words unto the ends of the earth. . . . Have there been any soldiers like unto him since his head fell upon Tower Hill on October 29th, 1618? That is the subject which I propose to discuss this evening."

In Raleigh's day the soldier was an amateur. The professional soldier came into his own during our civil war. The most lasting work for the army was, however, done by Cromwell, an amateur who was greater than any professional. His great work was to abolish the old tradition of war as a mere matter of money-making, and to raise the whole calling of the British soldier to a higher plane. The recruits he sought were "men who make some conscience of what they do." When these recruits had been turned into trained soldiers he describes them as "men who know what they are fighting for, and love what they know." "Are not these rugged words," says Fortescue, "a possession to our race for ever?"

* *The British Soldier and the Empire*, by THE HON. JOHN FORTESCUE, LL.D., Oxford University Press, Amen Corner, E.C. 2s.

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Taking these words as his text he follows up the influences of the great instructors of the British Army who carried on the work initiated by Cromwell—Marlborough, Wolfe, Moore, Wellington, Charles Napier, and " a certain taciturn inarticulate Scot who has held the very highest command and controlled the most tremendous issues, but is still to us little more than a name."

But it is not only the great names that Fortescue gives us in his study of the influence of the British Army. Colonel Mark Wilkes, author of the *History of Southern India*, Lieut.-Colonel Colin Mackenzie, collector of Southern Indian antiquities, Henry Rawlinson, the Assyriologist, William Martin Leake, the Gunner Colonel, " one of our great authorities upon classical antiquities, and a positive genius in the matter of topographical research," are amongst the less known names that he brings before us.

James Kempt and Benjamin D'Urban were two of Wellington's generals who became successful colonial governors; Harry Smith and Lord Seaton, admirable colonial administrators, had been trained in the Light Division by Sir John Moore.

As authors, beginning with Sir William Napier, historian of the Peninsular War, Fortescue gives us William Cobbett, author of *Rural Rides*, and of an English grammar " which for long was considered—and perhaps may still be considered—the best that ever was written." This is followed by " a devout wish " that the military profession would study this grammar, an aspiration not difficult to understand, coming as it does from a military historian who has in the course of his work had to read, compare and collate more military reports and literature than perhaps any man living!

After an interesting and inspiring summary of the character and influence of the British soldier from the days of Cromwell to those of Wellington and the early campaigns of the nineteenth century, he closes his lecture with the following words: " Since then the soldier has gone from strength to strength. Now he is anxious to go abroad and see the world, and wherever he goes, he takes order and good-nature with him. It matters not whether he hails from my own garrulous and affable Devon, or from the more taciturn and suspicious North country, he is the same. It is true that, when he is thoroughly comfortable, he can only find vent for his feelings in incessant grumbling, but that is simply the defect of his supreme qualities of cheerful patience in discomfort, and of charity towards all men. Whence this charity arises it is difficult to say; but I think that it has its true source in the feeling that he comes of a victorious stock, that he is very strong, irresistibly strong, and that therefore he can afford to be very gentle. An officer of very wide experience told me after the South African War that it was the most difficult thing in the world to make the British soldier kill a man; and the readiness to accept treacherous signs of surrender is

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a proof of this. However, the good nature—the charity—is there; and we do not realize what it has done for us. To give but one instance, our Allies at Salonica sent forth, quite legitimately, emissaries in every direction to gain the hearts of the people, and to lay a foundation for future commercial enterprise. We did nothing of the kind; and yet the people everywhere turned to us and wished to deal above all others with us. Why? Because the name of a British soldier was not to be found on the criminal charge-sheets of that polyglot army. The British soldier, though employed on a duty which subjected him to much hardship and sickness with no compensating chance of distinction, had always been not only well-behaved, but honest, gentle, and considerate. And so it was that quite unconsciously he outdid, by sheer force of character, the efforts of all other nations to commend themselves to the Balkan peoples. And this work, be very sure, he does wherever he goes. He is a silent missionary, but of power untold. Better than most of us, he has assimilated the precept, 'Be pitiful; be courteous;' more truly than most of us has he learned the difficult lesson of self-respect without self-consciousness. Such is the fine flower of the tree that was planted by Cromwell and watered not only by Marlborough and Wolfe and Moore and Wellington and Charles Napier, but by thousands of humble and earnest officers whose names have perished but whose works do follow them. The British soldier, supposed to represent physical force only, is a great moral force within and without the Empire. It is not with physical weapons only, nor even chiefly, that he contends all the world over for the honour, in the higher sense, of his regiment, of the Army, and of the nation. And he prevails because he makes some conscience of what he does. He knows what he is fighting for, and loves what he knows."

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CORRESPONDENCE.

THE TIBET MISSION OF 1903-04.

To the Editor, R.E. JOURNAL.

SIR,

It seems to be quite clear from the Blue Books that neither Major Morshead nor General Ferrier is quite accurate in his reference to the Tibet Mission of 1903-04. The former speaks of "the military and political expedition to Lhasa under Colonel Younghusband in 1904-05." The latter protests that "Colonel Younghusband was head of the political mission that accompanied the military expedition to Lhasa under the command of Brigadier-General J. R. Macdonald." Both writers are wrong in calling it a military expedition; it was a political mission with a military escort. Colonel Younghusband was the British Commissioner, and Brigadier-General Macdonald commanded the escort. The Blue Books are: Papers relating to Tibet, 1904, Cd. 1920; Further Papers relating to Tibet, 1904, Cd. 2054; and Further Papers relating to Tibet, No. III., 1905. Cd. 2370. It should be sufficient to quote from these the following phrases:—

Cd. 1920 No. 99. Secretary to the Government of India in the Foreign Department to Major Younghusband, 20 July, 1903. "Instructions have issued for the deputation of an escort of 200 men to accompany your Commission."

No. 112. Viceroy to Secretary of State, 16 September, 1903. "Colonel Younghusband is strengthening his escort."

No. 170. Viceroy to Secretary of State, 12 January, 1904. "Tibet Mission left Phari . . . accompanied by the escort."

Cd. 2370. No. 115. Secretary of State to Government of India, 5 August, 1904. "I desire to express the appreciation of His Majesty's Government of the courage and endurance of the troops attached to the Mission."

The language used throughout is consistent with these passages. Though the escort was increased until it became a considerable force, and though after the attack on the Mission at Gyantse the Foreign Secretary, Simla, telegraphed to the British Commissioner that "preponderance for the present must be given to military considerations, and General Macdonald has been authorized to take all measures necessary to secure safety of Mission" (Enclosure No. 77 in No. 97, Government of India to Secretary of State, 30 June, 1904) it is clear that the Mission retained its political status throughout, and was never regarded as a military expedition.

Yours very faithfully,

ARTHUR R. HINKS.

Royal Geographical Society,
19 February, 1921.

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REVIEWS.

NARRATIVE OF THE 502 (WESSEX) FIELD CO., R.E., 1915-19.

BY MAJOR C. L. FOX, M.C., R.E. (Hugh Rees, Ltd., 1920).

This is another publication in the interesting series of R.E. Company records which have begun to appear. It is the story of the experiences of the 502nd Field Co., R.E., from its formation in 1915 to its disbandment in 1919.

The unit was originally the 1/3 Wessex Field Co. and was formed under the late Major W. Jane. Major Jane was a Territorial officer of long standing, whom I knew personally as 2nd in Command of the 2nd Wessex Field Co. in the 27th Division, with which unit he was wounded at Armentières in the summer of 1915. We had the 1st and 2nd Wessex in the 27th Division in Armentières then and it is curious to note that the 502nd Fd Co., seems to have done a great deal of work on the same ground. I notice the name Rolanderie Farm particularly. In 1915 the 2nd Wessex (Jane's Company) built an advanced Div'l. H.Q. at this place and at the time it was one of the star jobs in that part of the world, with its reinforced concrete roof which 502 seemed to think was not thick enough and which they in their turn improved. Another item of interest is the account of " dowsing " or water divining having been resorted to during the great advance in 1918. The only other time that I know of this having been done by a Royal Engineer Unit was at Glen Imaal near the Curragh in 1912, when Captain Buckle, R.F.A., who was attached to the 59th Field Co., gave us great assistance in locating water by this method, which he had the power to use. The book is a faithful record of the work of a Royal Engineer Field Unit, written as a souvenir for the *personnel* of the unit and its friends. It shows throughout the cheerful optimism that carried the Sapper so far in the war and the kindly feeling between all ranks that kept us all together. The unit was in the field from February, 1917, to the Armistice, and during this period lost 2 officers and 74 other ranks killed and wounded, a light list I imagine, considering all they went through, pointing clearly to good leadership. There are two good maps and lists of *personnel*, on proceeding overseas and at the Armistice.

Now that these company records are beginning to appear, it seems desirable that some move should be made to collect the records of the regular field and other companies that served during the war.

G. WALKER, *Colonel Commandant.*

WIRELESS TELEGRAPHY AND TELEPHONY. AN OUTLINE FOR ELEC. ENGINEERS AND OTHERS.

BY L. B. TURNER, M.A., M.I.E.E. (Cambridge University Press. £1).

This is not a book for the " Wireless Amateur," or for the beginner in electricity who wishes to take up wireless. It is written for the Electrical Engineer who is at home in his alternating current theory and practice,

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and wishes to extend his knowledge to include the principles of wireless. It aims at showing how the new art is based on laws with which he is already familiar, extended to the region of high frequencies, and it should help to dispel the too prevalent idea that the subject is the thing apart, sacred to the initiated and to be regarded with awe by ordinary men. A peculiarity of wireless is its fascination for the amateur who has not been through the mill of a general electrical training, and the extent to which such a man can do really good work in it; a large number of text books have been written for his benefit but he reaches his limit where he is passed by the engineer with the broader grounding for whom this Outline is intended.

The arrangement of the book is unusual, but effective for the object in view. After a short introduction, pointing out among other things the order of frequency employed (commonly between 5×10^6, and 5×10^4 periods per second), the author proceeds to a simple analytical explanation of the fact that energy is radiated from any circuit when the current in it changes, negligibly in the case of ordinary A.C. practice but very appreciably in the case of wireless aerials. He claims that his aim is to convince of this fact rather than prove it, but the explanation given should satisfy any but the most hardened mathematician. Then, still before making any mention of the apparatus used, he discusses the wave nature of the energy thus liberated from a wireless sending aerial, traces its fate in surrounding space, and shows what portion of it may reach that speck on the earth's surface, the receiving station, concealed from the transmitter by the curve of the world. He then, in Chap. III examines the behaviour of oscillatory circuits in general, with the effects of inductance, capacity and resistance; he discusses decrement and methods of coupling and finally shows that a wireless antenna is an oscillatory circuit obeying the laws he has sketched out. Chapters IV to X explain the apparatus in general use for the production of oscillatory current of the sending aerial, and for the detection at the receiver of the ether waves set up. Most wireless text books dwell principally on the spark systems, which comprise perhaps 90 per cent. of the world's existing stations, describe fairly fully the arc and high frequency generator, and finally discuss the thermionic tube or triode as a new oscillation generator of great promise. Mr. Turner, on the other hand, gets his account of the first three systems behind him as soon as possible, as of great temporary importance but almost certainly obsolescent, and settles down to a very full description of the many applications of the triode in both sending and receiving. This arrangement, and the fact that he dwells on principles of action and avoids the detailed specification of apparatus should keep the book up to date for a number of years to come. The author goes on to a chapter on telephony, and finishes up with a discussion of miscellaneous subjects including his interpretation of the modern trend of development, with which no one in touch with events is likely to quarrel.

The book pays the reader the compliment of assuming he is as well up in the theory of his own work as the author in his, and many of the arguments in the analytical portions are condensed and by no means easy to follow. The author sets the pace over a country he knows

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well, but the reader may find himself forced to stop and think hard at many passages that he is evidently expected to take in his stride. This is perhaps no drawback, but rather the reverse, and the book well repays the close attention it demands; it contains less than two hundred pages, and in such a short outline the question of what to leave out becomes a very difficult one, on which no two writers are likely to agree; it is hardly a point for the reviewer to criticize, since if many obvious omissions were included the book would no longer be an Outline. It is admirably produced with excellent plates and clear diagrams, and is a valuable addition to the technical library both of the electrical engineer and the more specialized wireless expert.

R. CHENEVIX-TRENCH.

TALKS ON LEADERSHIP ADDRESSED TO YOUNG ARTILLERY OFFICERS. By BASILISK.

(London, Hugh Rees, Ltd., 5, Regent Street, S.W.1., 1921. Price 1s.).

Although addressed to young artillery officers these "Talks on Leadership" are eminently suited to interest and benefit young officers of all arms. The subject of leadership is dealt with in a concise, practical and thoroughly attractive manner.

NOTICES OF MAGAZINES.

REVUE DU GÉNIE MILITAIRE.

THE *R.E. Journal* has much pleasure in announcing the re-appearance of the *Revue du Génie Militaire*, the publication of which was suspended during the war, but has recommenced since January, 1921. It is published by the Librairie Berger-Lebrault, 18 rue des Glacis, Nancy, at the price of 4 francs per copy, or 48 francs post free (postal union), per annum. In an Introduction to the January number, it is stated that during the suspension of the *Revue* its place has been taken by 12 numbers of the *Bulletin de Renseignements du Génie*, published under the direction of the *Inspection Générale des Travaux et Organisations aux Armées.*

The present number contains the first part of a comparative study by General Benoit of the fortifications of Verdun and Metz. The General gives a detailed description of the latest development of the German *Feste* and traces its evolution towards a defensive function from a purely offensive one in 1899. It is hoped that the *R.E. Journal* will be able shortly to publish extracts from this instructive study. There are also a lecture on flame projectors and several interesting reviews, including one on the timber reinforcement of concrete, and a memoir on General Roques, the distinguished Commander of the 12 C.A. at the Meuse and the Marne, and later of the 1st and 4th Armies, and Minister of War, who died at Saint Cloud on 26th February, 1920.

F. E. G. S.

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MILITÄR WOCHENBLATT.

No. 27.—*Review of military and political events in* 1920.—The leading article, after the usual references to Germany's unconquered army, Wilson's hypocrisy, and the futility of the League of Nations, attributes all Germany's troubles to her defencelessness. It says that all that can now be done, is to use every effort to make the Reichswehr an efficient and trustworthy force.

France's measures to reconstitute her army are looked on with envy. She is considered a fortunate country to have been able, in these days of outcries against German militarism, to continue and enlarge her system of universal service; while Germany is an unhappy land, being unable to make use of this best of schools for her young manhood, in spite of having been the first to institute it.

Belgium's close connection with France is said to find but little favour in England, while France is said to consider Belgium's short six months training for her recruits, hardly enough to enable the latter country to fulfil her obligations.

The anxious moments which Poland caused France in 1920 are noted and it is expected that 1921 will see more of them, when the Bolsheviks find the country dry enough for campaigning. The Riga negotiations are considered a mere pastime for the winter months; no result is expected from them.

Serbia's sympathies are said to be as much for Russia now, as they were in the days of the Czar—another source of anxiety for France, who must learn that there is no room for gratitude, but only for self-interest, in politics.

The return of Constantine to Greece and the fall of the "Cretan adventurer" Venizelos is about the only bright spot the writer sees in 1920, though he still has hopes that the question of Cilicia and Syria, Ireland, and the Pacific will cause the thieves of the Entente to fall out so that honest Germany may, in 1921, come by her own.

The Black Plague.—The *M.W.B.* calls on all nations to stop France using coloured troops in the army of occupation. It says that she only does it to hide her real weakness, that it makes the lower races lose their respect for Europeans, and that the consequences for the whole civilization of the white races will be terrible.

No. 28.—*The revolutionizing of Germany in the world-war.*—Under this heading the *M.W.B.* discusses a recently published book called *Subterranean literature in revolutionary Germany* written by two members of the 3rd International.

The book recounts events from the 4th August, 1914, the day when the 2nd International died, and describes how pamphlets were secretly circulated, sometimes from hand to hand, sometimes pushed under doors or left in factories; this literature, which is extensive enough to fill a whole library, forms a complete picture of modern revolutionary propaganda. It is based on the principles laid down by Marx and will have nothing to do with a democratic revolution; this is described as an out-of-date relic of the French revolution, forgotten since the days

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of 1848. A socialistic revolution is the only thing for the up-to-date strifemonger. The defeatist ideas which were circulated, were not directed so much against war as such, as against a state of affairs which threatened to settle the *bourgeoisie* still more firmly in power. The leaders were Liebknecht, Rosa Luxemburg and Franz Mehring. To the first named much credit is given for the way in which he influenced the young recruits, and succeeded in rendering the two last called-up classes almost useless to the Army. In December, 1914, the English comrades were addressed, according to the book with success, though the *M.W.B.* is sceptical! In 1915 the German government took a hand in the game, called Liebknecht to the colours, put Rosa in gaol and suppressed Mehring's publications. In spite of this they managed to carry on their work and the organization for printing and circulating "Spartacus letters" was much improved. In March, 1916, some 18 social-democratic deputies formed a party of their own and thereby greatly strengthened the revolutionaries. May, 1916, saw Liebknecht imprisoned, but the organization was now strong enough to survive even this blow, and at the end of June it succeeded in getting the Berlin and Brunswick munition workers out on strike. Further strikes followed in April, 1917, and the work which had been devoted to demoralizing the Navy began to show results. The Russian revolution gave a great impetus to the revolutionaries, who now began to come out into the open. Enormous numbers of pamphlets were circulated among the troops at home and at the front, great emphasis being laid on the large American forces which were landing, and special efforts were made to counteract any effects which the German victories on the Chemin des Dames might be expected to have.

The second part of the book deals with propaganda which came into Germany from abroad. The *M.W.B.* says that this was mostly worked by the Entente, who found plenty of German traitors to do their dirty work for them. It regrets however that Ireland, India, Egypt and Persia, which would have provided Germany with such promising opportunities, were unattainable by her.

The *M.W.B.* hopes that the history of this important subject will be dealt with by the commission, which is examining the causes of defeat; and says that the monthly reports of G.O.C.s' districts would furnish much material for their consideration. It further recommends that the feelings of men in the reserve formations, in the transport service, the leave trains, the recruit depôts and finally in the units themselves should be carefully examined, so that the true causes of these sad events in German history may be laid bare.

The fear of a gap.—Julius Frontinus says that this fear was unreasonably strong on the German side. The pretty barrage maps, with every possible approach duly blocked by nicely coloured bands and ovals, encouraged this fear, even if they did assist the imagination of commanders. The principle has always been laid down that it is a good thing to surround your enemy. The logical sequel is, that if he is good enough to push his head into a hole so much the better, but this was forgotten. Germany clung too much to Linear strategy, partly through anxiety

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to use all available roads to their full extent, and partly because the difficulty of expanding a gap was underestimated. The writer says, rightly enough, that there is no danger in a gap—provided of course it is not too wide—so long as the flanks are strong and of good moral. He says that all the troubles of 1914 spring from lack of appreciation of this fact. Germany was so anxious not to be weak anywhere, that she was not strong enough anywhere, and to this weakness of character, for so he correctly names it, all her subsequent troubles were due. He says that whenever in France the German line was pierced the penetration was incorrectly dealt with. Instead of being attacked from the flanks, it was always pushed back from the front; this merely served to hasten its withdrawal from a dangerous position. An an instance he mentions the 30th Nov., 1917, at Cambrai, when the reserve of the 2nd Army was directed from Seranvillers *via* Crevecoeur in a due westerly direction.

On a large scale he says that the 1866 advance into Bohemia was an example of what should be done. This, he says, was due not to any special system of Von Moltke, but to his strength of character.

No. 29.—*The break-through on the Macedonian front in September*, 1918.—General von Zwehl says this was due to the Bulgarians having lost all heart for further resistance. Before the attack began 15 German battalions had been withdrawn to the Western front, and though they were replaced by more than that number of Bulgarian battalions, the deficiency could not thus be made good. On the 15th September there were, besides the German artillery and machine guns, only 3 German (jager) battalions on the whole Macedonian front.

The condition of the Bulgarians, as regards equipment and supplies, was pitiful; most of the men had no shirts or boots. There was practically no administrative service and each regiment looked after itself. The better condition of the German detachments gave rise to bad feeling, which the Bulgarian officers were at no pains to repress. The latter took little trouble over their men and mutinies were common.

When General von Steuben tried to effect a redistribution of troops, so as to strengthen the threatened front, the Bulgarians put every obstacle in his way, and said it was impossible to do anything because regiments would not leave the areas in which they had cultivated land, fearing that, if they did so, they would starve.

Even the superior officers were not free from distrust and conceit. When a divisional commander was recommended to prepare a defensive position in rear, he indignantly declined to do so, because, he declared, his men would never retire. Similarly an attempt to obtain better co-operation with the artillery was met by the abrupt refusal of a senior gunner to have any interference with his command. After the break-through a divisional staff was entirely lost both to its commander and the troops. The Bulgarians were worn out, but General von Zwehl thinks that their exertions before and during the war provide some excuse for them.

No. 30.—*The break-through on the Macedonian front in September*, 1918 (continued).—General von Zwehl declares that there was no surprise.

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The attack was foretold by Serbian deserters as well as by aeroplane reconnaissances.

Increased readiness for action was ordered, from the 7th September, and all possible measures taken, to prepare for the attack. The Bulgarian commanders were very confident that their troops would stand, but Sofia apparently had doubts, and sent many political chiefs and high officials to the front to exhort the troops to resistance. Reserves in the shape of complete divisions, were lacking, but there were several regiments available; these however could not be used for counter-attacks because their *morale* was so poor. It was unfortunate that the best Bulgarian divisions were not in the front attacked, but further to the West. When the attack came these divisions (of the 62nd Corps) easily repulsed the feints made against their front, but the break-through on the front of the 61st Corps made the situation difficult. However there was no immediate withdrawal of the 62nd because it was not thought possible that the 61st would go back as fast as it actually did.

On the 21st September (the attack having been launched on the 15th) the left wing of the 62nd Corps began to fall back and was followed by the whole western part of the line. The Corps intended to retreat *via* Kalkandelen and Uskub, but, delayed by immense baggage trains and bad roads, found the latter place already occupied by the Allied advanced guard. Weak though these were, they sufficed to cut off the Western troops and though the German and Austrian detachments mostly got away north, the Bulgarians had to lay down their arms under the terms of the Armistice. The first reinforcements from Germany and Austria could not reach Uskub, or Kumanov as had been intended, but had to detrain at Vranje. They could do nothing to prevent the catastrophe.

General von Zwehl does not wish to depreciate the value of the Bulgarian Army, which had been through much before the Great War began, but he thinks that the German defeats in France in July and August had made many Bulgarians begin to wonder if they had not backed the wrong horse. This feeling was fostered, he says, by the American ministry which was very foolishly allowed to remain in Sofia, the Bulgarians being unable to bring themselves to break with the United States.

Von Zwehl says that discussion of the collapse on the Macedonian front, raises once more the question as to whether it would not have been better, when the brilliant Serbian campaign brought the central powers to the Greek frontier in 1915, to have pushed on and occupied Salonika.

Von Falkenhayn decided against this on political as well as on military grounds and this decision was in accordance with his general idea of limiting German commitments in the East as much as possible. Von Zwehl thinks he was right and only regrets that similar moderation was not shown elsewhere.

L. CHENEVIX-TRENCH, *Major, R.E.*

14th March, 1921.

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REVUE MILITAIRE SUISSE.

October, 1920.

NOTES AND NEWS.

France.—Two important questions are under consideration by a Commission; (1) the general organization of the army, and (2) recruiting. It is probable that the Commission will recommend that the present general organization be retained, whereby France is divided into 20 military regions; some slight alterations of the sub-areas may be involved to meet recruiting requirements and the exigencies of a mobilization. It is expected that both the division and the army corps will form a permanent part of the peace organization; higher formations will only come into existence on mobilization. In a draft law, which has been prepared, provision is made that in future all officers, whether on the active, reserve or territorial list, shall be eligible for promotion to the highest rank in time of war. Provision is made in the draft recruiting law, now under consideration for service with the colours being reduced to 18 months from 1922, provided that (1) the number of professional soldiers (exclusive of officers) can be maintained at 80,000 to 100,000 men in 1923; (2) the number of native soldiers can be raised to 300,000 men (there are only 100,000 at present); and (3) a civilian corps can be recruited to carry on the "services" in the Army.

No. 11.—*November*, 1920.

Ski-ing Competitions.—Colonel Grosselin deals in the original article with a ski-ing competition in which the Swiss 1st Infantry Brigade took part recently at St. Croix. He doubts the military value of competitions of this kind for the purposes of tactical training, which, in his opinion, can be better effected by means of the ordinary tactical schemes carried out against a marked enemy in the open weather of the spring and summer months. On the other hand, he entirely approves of such competitions as a form of gymnastic contests, and expresses the hope that the Swiss War Office may soon lend to military ski-ing competitions the same countenance and encouragement that it does at the present time to rifle shooting and other similar forms of sport.

Indirect Machine-gun Fire.—Captain Monod states, in the original article, that it is now customary to employ machine-guns in large batteries of from 120 to 150 pieces grouped directly under the orders of a Divisional M.G. Commander, and that, in such circumstances, indirect fire has been resorted to with good effect up to ranges of from 3,000 to 3,500 metres, and in exceptionally favourable cases up to a range of 4,000 metres. The gun laying has in such cases been effected by means of maps; and a description of the methods employed, and also a list of the special materials and appliances necessary for the purpose are given in the original article. The tactical employment of machine-guns in large groups in offensive and in defensive Warfare is also briefly touched upon.

NOTES AND NEWS.

Switzerland.—The new Swiss regulations entitled *Principes à enseigner dans les écoles et les cours de* 1920 *pour la préparation au combat*, are, it

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is stated, inspired by the doctrines which prevail in Germany. The contributor of the original notes points out that the French regulations on military training have met with universal approval both in France and abroad, and suggests that the Swiss military authorities should accept the principles worked out in France as the basis for the instruction of the Swiss Army rather than the politico-military tactical principles of Ludendorff, which, even in Germany, have been, to some extent, rejected by serious students of war.

United States of America.—A special correspondent deals with the Military Service Act passed by Congress on June 4th, 1920; this Act, in a general way, modifies and effects improvements in the provisions made in the Act of June 3rd, 1916, which constitutes the organic military law of the United States. By the new Act the peace establishment of the American Army is raised from 175,000 to 280,000 men. The former term of Army service was 7 years—3 with the colours and 4 in the reserve—but to-day men may engaged either for one year or three years, according to their wish, and there is no longer any obligation to serve in the reserve. The reserves now consist of (1) the Reserve of Officers, and (2) the Enlisted Reserve, *i.e.*, men belonging to certain trades who, whilst not willing to serve with the colours are prepared to enter the service as reservists. The Reserve of the National Guard, instituted in 1916, is continued in existence. Among the most important of the changes introduced by the new Act is the creation of chiefs for each arm and for each of the services. The formation of a "Chemical Warfare Service" and of an "Air Service" is also sanctioned. The General Staff has been reorganized and divided into two branches: the Staff of the Ministry of War and the Staff with formations. In future officers will require to possess the certificate of the newly-created Staff College to be eligible for staff appointments. A new system of promotion has also been introduced: henceforth there is to be a single seniority list. Brigade commanders are to be promoted from a list of Colonels selected each year by a Committee consisting of 5 Divisional Generals.

W. A. J. O'MEARA.

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PROBLEMS

PROBLEM 22 (Solution).

SUM the series $\sin 2x - \frac{1}{2}\sin 4x + \frac{1}{3}\sin 6x$ to infinity.

If S be sum of series

$$2\sqrt{-1}\,S = e^{2x\sqrt{-1}} - e^{-2x\sqrt{-1}} - \tfrac{1}{2}\left(e^{+4x\sqrt{-1}} - e^{-4x\sqrt{-1}}\right) + \text{etc.}$$

$$= a - \frac{a^2}{2} + \frac{a^3}{3} - \text{etc.}$$

$$-\left(b - \frac{b^2}{2} + \frac{b^3}{3} - \text{etc.}\right)$$

where $a \equiv e^{2x\sqrt{-1}}$ and $b \equiv e^{-2x\sqrt{-1}}$

$$= \log(1+a) - \log(1+b)$$

$$= \log\frac{1+e^{2x\sqrt{-1}}}{1+e^{-2x\sqrt{-1}}}$$

$$= \log\frac{1+\cos 2x + \sqrt{-1}\sin 2x}{1+\cos 2x - \sqrt{-1}\sin 2x}$$

$$= \log\frac{\cos x + \sqrt{-1}\sin x}{\cos x - \sqrt{-1}\sin x}$$

$$= \log\frac{e^{\sqrt{-1}x}}{e^{-\sqrt{-1}x}} = \log e^{2x\sqrt{-1}}$$

$$= 2x\sqrt{-1}.$$

$\therefore$ $$S = x.$$

SOLUTIONS.

A solution to Problem 22 adjudged correct has been received from Major F. C. Westland, and correct solutions without analysis of Problem 23 from "x" and Captain C. J. E. Greenwood, M.C., R.E. Major P. G. H. Hogg, D.S.O., R.E., has sent a correct analysis with 3 numbers correct.

J. M. WADE, *Lt.-Col.*

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NAPOLEON'S ENGINEERS.

By BRIG.-GENERAL J. E. EDMONDS, C.B., C.M.G. (*retired* R.E.).

I CANNOT recall having ever heard of or seen any book specially devoted to the engineers of Napoleon's armies. On consulting my colleague in the Historical Section, Major F. A. Becke, late R.F.A., a great collector of Napoleonic literature, I found that he also had never come across anything of the kind. He said, however, that he was the fortunate owner of a curious little book entitled, "Etat du Corps Impérial du Génie," Mai, 1808, in which there was a good deal of information regarding the organization of the French engineers. His copy is of special interest to us as it is inscribed, " Taken by Lieut.-Colonel Burgoyne, R.E., from the office of the French Commanding officer of Engineers, Madrid, 1812." The book is a small one ($7\frac{1}{2} \times 4\frac{1}{2}$) and has a preface headed " Précis de l'histoire des arts et des institutions militaires en France," written by M. Allent, *chef du bataillon du Génie*, containing a useful historical summary. From a few other books in Major Becke's possession, a list of which is given at the end of this article, some further material was gleaned. For any value therefore attaching to this investigation I am indebted entirely to him. It does not pretend to be exhaustive, but it may encourage someone else in studying Napoleon's methods to note how he employed his engineers, which it never before occurred to me to do.

Until 1793 the Artillery and Engineers of the French Army formed one Corps, as they had once in the British ; it was not, indeed, until after the war of 1870-1 that the bridging trains and troops ceased to belong to the Artillery. In October, 1793, Carnot, himself an Engineer, proposed to the Convention that the companies of miners should be separated from the Artillery. The separation actually took place on 15th December, 1793 (25 Frimaire, An II), and on the same day the formation of 12 battalions of sappers was decreed. This date therefore is the birthday of the Corps of Engineers of the French Army.

In Italy in 1796, Colonel Chasseloup-Laubat commanded the Engineers. In Egypt, 1798, there were 800 sappers under command of General of Division Caffarelli-du Falga, and, after his death during the Siege of Acre, of Sanson, who will be heard of again.

In 1800 in Italy, Général de Division Marescot was Chief Engineer, where he distinguished himself during the crossing of Mont St. Bernard, and we find him in the same appointment at

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the camps of Boulogne in 1805, with a staff of 17 officers and an A.D.C. By this time each Army Corps had an Engineer staff and each division a *chef de bataillon* and a company of sappers, and the recognized duty of the sappers in battle was to follow up an attack and put villages in a state of defence as they were captured; there was no better strong point than a well loop-holed building in those days. The miners were apparently specially trained in demolitions as well as in military mining.

In 1806-7 General of Division Chasseloup was Commandant-in-Chief of the Engineers, with a staff of 19 officers, including an A.D.C. The total strength of the Army is given as 335,100 on 1st April, 1807, and the strength of the Engineers as 2,382.

We now come to the Corps of Engineers in 1808 as given in the *Etat du Corps* captured by Lieut.-Colonel Burgoyne. It was then composed of a Staff, Engineer troops, and Fortress Wardens. Its organization was as follows:—

STAFF.

Chief Inspector General	1
Inspectors General, Generals of division	2
,, ,, ,, brigade	6
Total	9

Note.—These general officers formed part of the general staff of the Army.

Colonel Directors		41
Sub-directors—Majors	8	
Chefs de bataillon, 1st class	58	
,, ,, 2nd class	8	
		74
Captains, 1st class		100
,, 2nd class		120
Lieutenants		40
Total		375

SCHOOL.

One examiner of the Engineers, member of the Institute.
Students, sub-lieutenants of Engineers, 30.

Note.—The students were all graduates of the École Polytechnique the number varied with the requirements of the Service.

ADMINISTRATION.

Chief Inspector-General.—His Excellency General Marescot, Sixth Division of the Ministry of War.

ENGINEER PERSONNEL.

Director.—Chef de bataillon de Caux.
Chef de bureau.—M. Lagé.

ENGINEER MATERIAL.

Director.—Colonel Director of Fortifications Senermont.
Chef de bureau.—M. Schilleman.

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CENTRAL COMMITTEE ON FORTIFICATION.

President.—The Chief Inspector General.

Members.—The Inspectors General of Paris and field officers nominated by the Minister, eight in all.

Secretary.—Chef de bataillon Allent (no doubt the author of the Preface to the book).

CENTRAL DEPÔT OF FORTIFICATIONS AND OF RELIEF-PLANS OF THE FORTRESSES.

A director, sub-director and chef de bureau.

DEPÔT OF THE COLONIAL FORTIFICATIONS.

A director and chef de bureau.

ENGINEER TROOPS.

The Engineer troops were composed of five battalions of Sappers, five Train detachments, and nine companies of Miners.

Sapper Battalions.

Each Sapper battalion was organized with a regimental staff and nine companies, 612 strong on peace and 1,377 on war establishment. The regimental staff both in peace and war consisted of a chef de battalion, a quartermaster, an adjutant, a surgeon-major, an assistant adjutant (non-commissioned), a corporal drummer, sergeant-tailor, sergeant shoemaker, and sergeant armourer, nine in all.

Each company consisted of the following on both peace and war establishment:—Captain 1st class, captain 2nd class, lieutenant 1st class, lieutenant 2nd class, sergeant-major, 4 sergeants, and a quartermaster-sergeant. In the other ranks the establishment differed.

	Peace	*War*
Corporals	4	8
Master-tradesmen	4	8
Sappers, 1st class	12	36
Sappers, 2nd class	36	88
Drummers	1	2

Making a total of 67 all ranks per company in peace, and 152 in war.

How many vehicles a battalion possessed does not appear, but the battalion train detachment contained a sergeant-major, a sergeant, four corporals, a shoeing smith, a saddler, and 60 train soldiers.

The Miners had only a company organization; with the same number of officers and sergeants as a Sapper company.

	Peace	*War*
Corporals	4	4
Artificers	4	4
Miners, 1st class	12	24
Miners, 2nd class	36	56
Drummers	2	2

Total per company 68 in peace and 100 in war.

Why a Miner company should require two drummers on peace establishment and a Sapper company only one, is not apparent.

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FORTRESS WARDERS (*Gardes du Génie*).

These were no doubt foremen of works. There were four classes.

1st class, warrant officers	74
2nd class, sergeant majors	74
3rd class, sergeants	150
4th class, corporals	290
	588

At the time of publication of the *État* the following officers held the higher appointments in the Corps:—

Chief Inspector General.—His Excellency General Marescot.

Inspectors General and Generals of Division:

Chasseloup-Laubat, Director General of Engineers in Italy.
Lery, Commandant of Engineers of the Army in Spain.
Bertrand, A.D.C. to the Emperor.
Sanson, Director of the General War Depôt.

There were on the strength of the Corps 9 generals of brigade; 42 colonels directors of fortifications; 7 majors, sub-directors; 75 chefs de bataillon, 330 captains, and 119 lieutenants; and the total war establishment of the Corps was 9,088.

The *Etat* gives a complete nominal roll of the officers by ranks, and in the case of the Staff, where each officer was employed. The French Engineer officer who owned the copy evidently took an interest in promotion, for he had kept the list up to date by crossing out the names of those who died or were killed, and by noting changes in rank.

In 1808 the distribution of the Corps was as under:—

Sappers.

1st Battalion Staff, Alessandria.

1st Co., Elba
2nd Co., Mantua
3rd Co., Dalmatia
4th and 5th Co., Palma Nova
6th to 9th Co., Alessandria

2nd Battalion with the Grand Army (1st Co. at Palma Nova)

3rd Battalion, Staff, Alessandria.

1st Co., Corfu
2nd, 4th and 5th, and 9th Cos., Alessandria
3rd Co., Gaeta
6th Co., Dalmatia
7th and 8th Cos., Army of Naples

4th Battalion, Staff, Juliers.

1st Co., Warsaw
2nd Co., VI Corps of the Grand Army
3rd, 5th, 6th and 8th Cos., Berlin
4th Co., Custrin
7th Co., IX Corps of the Grand Army
9th Co., Mayence

5th Battalion, Staff, Mayence.

1st. Co., Danzig
2nd Co., Hameln
3rd Co., Stettin
4th and 6th Co., Erfurt
5th Co., Hamburg
7th Co., Thorn
8th Co., Spandau
9th Co., Stralsund

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Miners.

1st Co., Palma Nova	3rd Co., Metz
2nd, and 4th to 7th Cos. with the Grand Army	8th Co., Mayence
	9th Co., Wesel

The list of stations indicates how thoroughly Prussia was occupied by the French, and yet she was able to organize a powerful Army.

Passing on to the years after the publication of the *État*, the following particulars are available.

In 1809 General Bertrand, A.D.C. to the Emperor, was Commandant-in-Chief of the Engineers with a staff of 22 officers.

On 30th June, 1812, on crossing the Nieman into Russia, the Sappers and Miners with the Grand Army totalled 13,932, the strength of the whole force being about 600,000. The Chief Engineer at G.H.Q. was General Chasseloup-Laubat and General Sanson was head of the Topographical Section. The Chief Engineers of Corps were: Guard, Kirgener; I, Haxo; II, Blein; III, Dodé de la Brunerie; IV, Poitevin; V, Pelettier; and VIII, Alix, who commanded both Artillery and Engineers.

No doubt the Sapper Companies gave a hand in the bridging of the Berésina in the great retreat, but the operations were in charge of General Baron Eblé of the Artillery, commandant of the bridging trains of the Grand Army and his 400 pontoneers.

In 1814 the Engineers were re-organized into 3 regiments of Sapeurs-Mineurs, each of two battalions.

In the Waterlooo Campaign, Lieut.-General Baron Rogniat, who was chief Engineer in 1813, was Commandant-in-Chief of the Engineers, and Colonel Bonne director of the Topographical Section.

The Engineers were allotted for the most part to Corps:—

Imperial Guard: Sappers, 3 Officers and 109 O.R.

I Corps (D'Erlon) C.E., Maréchal de Camp Baron Garbé—
5 Companies of the 2nd Bn., 1st Regt.=21 officers and 330 O.R.

II Corps (Reille) C.E., Maréchal de Camp Baron de Richemont—
5 Companies of the 1st Bn., 1st Regt.=22 Officers and 409 O.R.

III Corps (Vandamme) C.E., Maréchal du Camp Nempde—
2 Companies of the 2nd Bn., 2nd Regt.=7 Officers and 146 O.R.
Each of the three divisions had a half or a whole Company of these.

IV Corps (Gérard) C.E., Maréchal du Camp Valazé—
3 Companies of the 2nd Bn., 2nd Regt.=7 Officers and 201 O.R.
Two of the three divisions had a Company attached; the third Company was with Corps troops.

VI Corps (Lobau) C.E., Maréchal du Camp Sabatier—
3 Companies of the 1st Be., 3rd Regt.=7 Officers and 189 O.R.

There were thus 67 officers and 1,384 Sappers in the Armée du Nord, the total strength of which was 122,408 with 350 guns.

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DRESS.

The dress was a dark-blue (apparently) tailed coatee with epaulettes, well cut-away in front and showing a buttoned waistcoat; dark-blue breeches, and high white buttoned gaiters, covering the knee. The full dress head-dress was a heavy-looking bell-topped shako with pompom and plume. There was also a double-decked field service cap. White crossed belts, one for the bayonet, and one for the pouch. A musket was carried, but apparently, unlike the modern Sapeur, no tools were part of the man's burden.

The Sappers of the Guard were distinguished by red turnbacks, facings and pipings, and wore a magnificent brass helmet, with an eagle in front and side scales. It had a tall dark plume with a white-hackle.

For sapping and close work in the attack of fortresses the Engineers had an iron pot helmet with hinged ear-pieces and back-flap, not unlike the head-dress of Cromwell's Ironsides. They were also provided with iron breast and back-pieces, which buckled together.

The Artillery seem to have been distinguished by short jackets and dark gaiters.

AUTHORITIES.—*État du Corps Imperial du Génie* (1808).—*Types et Uniformes de l'Armée Française*, 1789-1884. Détaille et Richard (1885-9).—*Historiques des Corps de Troupe de l'Armée Française*, 1569-1900 (1900).—*Les derniers jours de la Grande Armée*, 1813, 1814 et 1815. Capitaine H. de Mauduit (1847).—*Campagne de l'Armee de Réserve en* 1800. Capitaine de Cugnac (1900).—*Histoire populaire de la Garde Impériale*. E. M. de, Saint-Hilaire (n.d.).

French pontoon equipment is shown in *Etudes sur le Passé et l'Avenir de l'Artillerie, Prince Napoléon et Colonel Favé.*

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A SCIENCE OF INFANTRY TACTICS.

A lecture delivered at the S.M.E. on 6th Jan., 1921, *by* CAPTAIN B. H. LIDDELL HART, K.O.Y.L.I.

(*Concluded*).

THE EXPANDING TORRENT SYSTEM OF ATTACK AGAINST DEFENCE DISTRIBUTED IN DEPTH.

We have dealt so far with the principles of attack on any one body or centre of resistance of the enemy.

In modern war, however, armies are distributed in great depth; and the attackers are faced with the problem of breaking through a series of positions extending back in layers to a depth of several miles.

To this problem, an effective and scientific solution has yet to be found. Moreover, every defending infantry-unit also is itself distributed in depth in successive posts. We need to invent a system which will ensure—as far as is humanly possible—that our attack sweeps through and overwhelms the successive layers of the defence with an unslackening momentum combined with a minimum loss of men.

We have learnt by bitter experience, that it is sheer waste of force, when we come against an enemy position, to press our attack equally at all points.

We must feel and test the position everywhere, and endeavour to push in the weight of our reserves where a weak spot is found or made. This principle has been definitely established and the problem yet to be solved is our tactics when an initial breach has been made at any point in the first layer of the defence.

On the one hand, if we press forward at full speed beyond the gap without attempting to widen it simultaneously, it is risky. We lose the *weight* of our blow because we cannot push adequate reserves through a bottle neck. We lose *time* because the passage through a narrow gap causes delay and confusion. We *endanger our security* because we leave the enemy on our flanks untouched, and so able to cut off the head of our advance.

On the other hand if we halt our advance while we widen the breach, we lose *time*, the advantage of *surprise* and the *opportunuity* of exploiting our initial success, thus allowing the enemy time to organize strong resistance in rear, and await us. Hence we must create a scientific system of attack which will reconcile and combine **speed with security.**

The breach must be *widened in proportion as the penetration is deepened*, by automatically progressive steps beginning with the platoon and working up to the brigade.

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Such a system I have endeavoured to deduce by examining and analysing Nature's method of attack.

If we watch a torrent bearing down on each successive bank or earthen dam in its path, we see that it first beats against the obstacle feeling and testing it at all points.

Eventually it finds a small crack at some point. Through this crack pour the first driblets of water and rush straight on.

The pent up water on each side is drawn towards the breach. It swirls through and around the flanks of the breach, wearing away the earth on each side and so widening the gap.

Simultaneously the water behind pours straight through the breach, between the side eddies which are wearing away the flanks.

Directly it has passed through, it expands to widen once more the onrush of the torrent. Thus as the water pours through in ever increasing volume the onrush of the torrent swells to its original proportions, leaving in turn each crumbling obstacle behind it.

Thus Nature's forces carry out the ideal attack, automatically maintaining the speed, the breadth, and the continuity of the attack. Moreover the torrent achieves economy of force by progressively exploiting the soft spots of the defence.

By applying this natural system to battle I deduce these principles for the attack against defence in depth :—

i.—The forward sub-unit which finds or makes a breach in any of the enemy's positions should go through and push straight ahead so long as it is backed up by the manœuvre body of the unit.

ii.—The forward units on its flanks who are held up should send their manœuvre bodies towards and through the breach. These will attack the enemy in flank, destroy his resistance and so widen the gap.

iii.—Meanwhile, the units in rear press through the gap and deploy (expand) to take over the frontage and lead the advance in place of the temporarily held up units.

iv.—The held up units, as soon as they have accounted for the enemy opposing them, follow on as manœuvre units to support the new forward units.

(*N.B.* If the forward units are able to clear away the enemy opposing them before the rear units have passed through the gap they will naturally continue to lead the advance.)

Thus an automatic and interchangeable system of attack will be achieved. This system is applicable to all units and formations from the platoon upwards.

Taking for example the infantry attack : the left forward platoon of a company might find or make a gap whilst the right platoon was held up (*see Plate I.*). It would press straight ahead, whilst the company commander moves towards the gap with his manœuvre

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platoons (*see Plate II*). The held up platoon is still engaged with the enemy resistance, when the company commander has passed through the gap. He will therefore send one of his manœuvre platoons forward and to the right to take over the frontage of the held up platoon and carry on the advance in its place (*see Plate III.*).

If the company commander judges that the held up platoon can destroy the enemy resistance by its own resources, he will press on at once with his remaining manœuvre platoon, to back up the forward platoons.

If not, he helps the held up platoon by a flank attack before following on.

In any case, directly the enemy has been destroyed the checked platoon would follow on as a new manœuvre platoon.

The company commander would be ready to repeat this method against each successive position of the enemy, thus ensuring the relentless momentum of the torrent. (*See Plate IV.*).

Likewise the battalion commander may infiltrate his manœuvre company through the gap made by an advancing forward company to expand the front and replace another forward company whose advance is checked or delayed.

Thus any gap in the defensive system will be progressively enlarged and deepened on the initiative of each successively higher commander.

The battle tactics of infantry will become automatic and depend less and less on fresh orders from superiors in rear. Moreover artificial geographical objectives will be restored to their right position as mere stepping stones in the advance. We shall fulfil the principle of economy of force by concentrating our efforts on the only true objective—the enemy.

Thus we see that the respective phases of **Reconnaissance, Fixing** and **Decisive Manœuvre** will be carried out against each successive resistance, whilst the "expanding torrent" will ensure that the momentum of the attack is not lost by the delay caused by the clearing of these enemy defence posts.

Maxim i. No forward unit must however press on even if it finds a gap unless it has cleared, or made arrangements to clear, all enemy resistance within its frontage.

Maxim ii. To ensure good team work in the confusion of battle every unit commander, separated from his own superior, who finds another similar unit in front of him engaged in fixing the enemy, must be ready to act as a manœuvre body to the unit in front. To this end he should get in touch with the unit in front and find out if the latter requires him to aid it by a decisive manœuvre.

Maxim iii. In the case of the platoon, its commander must remember that his sections are not tactical units. This means that they are not composed of interdependent fighting parts and so capable

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of fixing and manœuvring simultaneously. They possess no manœuvre body of their own, and therefore the platoon commander must use his own manœuvre sections to help any of his forward sections which are held up, before continuing his advance.

Maxim iv. The forward section therefore which finds or makes a gap should only make a bound as far as the nearest tactical point from which it can cover and hold open the breach. It will not move on until it sees the rest of the platoon coming on to back it up.

Maxim v. In the attack against a large force distributed in depth, the expanding torrent system will abolish the need for battalion pursuit. Hence the battalion commander may use his reserve company, also, for replacing forward companies.

Three outstanding advantages of this system are firstly that an automatic continuity of the pressure of the advance is ensured, secondly that the expanding of the front of the advance rests with the immediately superior commander, thus ensuring that tactical unity is preserved instead of an unorganized dog fight to get forward, with each unit playing for its own hand; thirdly that the units which lead the advance will automatically be those which have encountered the least opposition. This will mean that the leading infantry are those which are freshest and have the most ammunition. It will be far easier to supply extra ammunition to those who have fallen behind than to those who are leading the advance.

INFANTRY IN DEFENCE.

The defence is simply the attack halted. **Any unit which halts its advance is capable on account of its open and self-contained formation of offering an immediate resistance to any hostile attack or counter-attack.**

Thus it resembles our simile of the human tank, possessing both the power of offence and defence. It only remains for it to consolidate the ground within its area so as to gain the most cover and best field of fire.

Once we have grasped this obvious truth the whole problem of tactics in general, and defence in particular, will be vastly simplified. Our previous method of creating a complex system of watertight compartments for each tactical action appears truly unscientific.

From this realization that defence is the attack halted, we deduce the truth that the five battle principles of protective formation, reconnaissance, fixing, decisive manœuvre and exploitation are equally applicable to the defence as to the attack.

A.—PREPARATION.

I.—FORMATION.

This will be generally similar to that of the attack. The company and platoon will be distributed into a forward body and manœuvre body. The battalion or higher formation into a forward body,

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manœuvre body, and reserve. The reserve will consolidate a final position of resistance for the battalion, or brigade.

Maxim i. Each unit in defence should be allotted an area to hold, and not a definite point. Thus if the enemy takes a defence post at a disadvantage, by crushing shell fire, smoke or manœuvre, the commander should use his initiative to quit the post and take up a fresh position on the flanks of the post so that he can out-manœuvre the attacking infantry.

Maxim ii. One difference in regard to the formation in defence will be that the manœuvre bodies can be previously placed in readiness on a rear flank of the forward body.

They should be placed to cover with enfilade fire the flank on which it is most likely that the enemy might break through. They should take up a position from which they can best sweep the breadth of their area with fire.

Maxim iii. The actual distribution in defence will depend mainly on the frontage and the field of fire. Two sub-units forward and two for manœuvre will be normal, but if the field of fire is restricted it will be best to place three sub-units forward and one for manœuvre. The essential need is to cover the whole area with intersecting rays of fire from the posts of the sub-units. A diamond formation, modified according to the ground, is very suitable for the forward platoons in defence.

Maxim iv. It will be advisable for all forward, or stationary defence, platoons to consolidate in section posts in order to cover more ground with fire.

Maxim v. In the case of manœuvre platoons it will normally be advisable for them to consolidate in platoon posts so that they may be kept more concentrated ready for manœuvre.

The "Contracting Funnel" in Defence.

Just as manœuvre is far superior to frontal attack, so manœuvre fire which enfilades the enemy from a flank is the most damaging both in material effect and to the attackers' moral. It represents the main sub-principle of economy of force, which is surprise. Thus the defence should be so disposed as to develop their greatest fire effect to the flank. To this end it should be our aim so to dispose infantry for defence, that the attacking enemy is encouraged to penetrate into channels in which he can be raked by flanking fire.

One step towards this is to site our Lewis and machine gun posts to mutually support each other with fire, rather than to fire direct to the front.

Another is the placing of manœuvre bodies so that they fire mainly to a flank.

A third way is to *echelon* backwards the posts of the manœuvre

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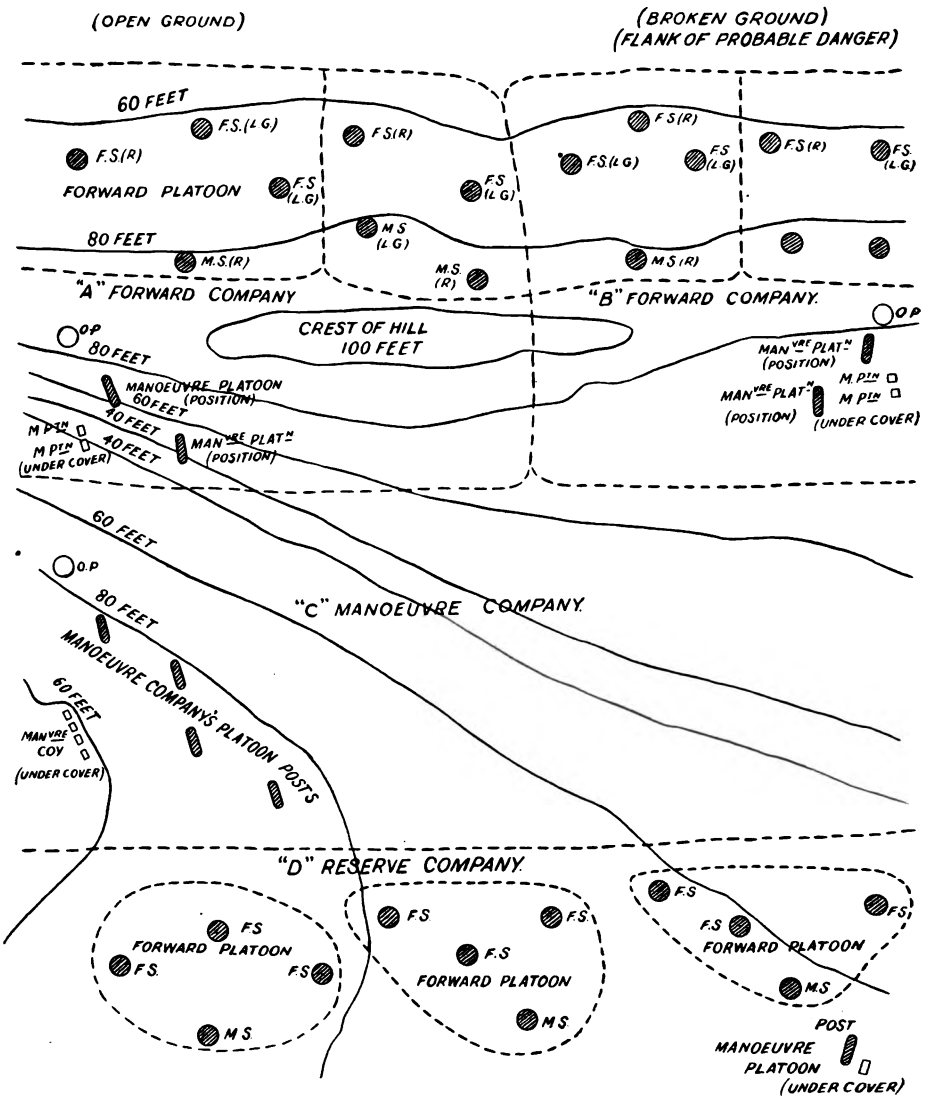
platoons and companies along the natural channels of approach to form a gradually contracting funnel raked by fire. Thus the further the attacker penetrates the more resistance he encounters and the more confined becomes the space in which he can manœuvre.

A diagram of a battalion disposed for defence may make the idea clear.

EXAMPLE OF A BATTALION HOLDING A POSITION IN DEFENCE.



If we study such a disposition, it becomes apparent that the only effective counter to such defence is the "continually expanding torrent" system of attack.

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II.—Reconnaissance.

i.—Preparatory reconnaissance will be carried out on similar lines to that for attack. Each commander both before taking up a definite position and during its occupation should study all available information, personally survey the ground and the possible ways of manœuvre, and send out company scouts on special missions.

ii.—Battle reconnaissance will be carried out mainly by patrols.

Maxim i. If not yet in contact with the enemy they should be sent out to keep watch on all likely lines of approach.

Maxim ii When in contact with the enemy as in position warfare, they will be sent out at night, in fog, or in dense country by day to keep his forward defences under observation, discover his dispositions, and give warning of a likely attack.

Maxim iii. They should usually be supplied by manœuvre or reserve bodies.

Maxim iv. In darkness or fog, patrolling is the best means of protection from surprise, and not the massing of more infantry in the forward positions.

Maxim v. Patrols and observation posts should be used by manœuvre and reserve bodies during an enemy attack to obtain information as to the situation in front and flank, and so enable instant and correct action to be taken.

III.—Fixing.

Defence in itself is one method of fixing the enemy. It is incapable of beating him, and therefore a defensive attitude will only be assumed in order to fix and weaken the enemy so that another force may be able to attack the enemy decisively elsewhere, or that you may yourself attack later when his vigour is spent.

In the actual infantry defence the phase of fixing is carried out by the forward bodies. If the forward and manœuvre companies of a battalion fail to fix and break up the enemy's attack, it will be the duty of the reserve to fix him in order to allow higher formations to decisively manœuvre against him.

Maxim i. Forward bodies holding positions should defend to the last man and the last round the area allotted to them.

Maxim ii. To instil this idea that troops who have consolidated should not withdraw, fighting patrols should be detailed from the reserve if it is desired to harass the enemy's attack before the main positions of resistance are reached. Moreover troops who have consolidated are more likely to hold on too long, and so if allowed to withdraw would mask the fire of the posts in rear when they fall back.

Maxim iii. The *rôle* of forward bodies is stationary defence by fire.

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Maxim iv. The commander of any forward section must however be ready to quit the post and take up a position on its flank, if the enemy take it at a disadvantage by shells, smoke or manœuvre.

B (IV).—DECISIVE MANŒUVRE.

The manœuvre bodies carry out the decisive manœuvre in defence as in attack.

If the enemy makes a gap or effects a lodgement in the positions of the forward body, the manœuvre body will make an immediate counter-attack to throw him back, or manœuvre by fire to close the breach and destroy him in a contracting funnel.

The function of its commander is manœuvre, which does not necessarily imply assault.

The commander of a manœuvre company or platoon has a choice of two main alternatives :—

i.—If the enemy break through the forward positions quickly and on a broad front, it will be best for him to man his prepared positions to take the enemy in flank by fire.

ii.—Otherwise he should manœuvre either to assault or fire.

Maxim i. A counter-assault which fails is a sheer waste of force. Hence it should not be launched unless the enemy is engaged with other defending units.

Maxim ii. Lewis gun sections of a manœuvre platoon may be used to surprise and fix the enemy with fire while the rifle sections assault.

Maxim iii. If the company commander decides to manœuvre to fire he should move to suitable positions on the flanks of the enemy's breach from which he can enfilade them.

Maxim iv. Above all he must remember that whether he uses fire or assault, or both, it will be most effective if delivered against the flanks of the enemy's wedge of attack. In this way the flanks of the breach will be strengthened and his advance cut off.

Maxim v. A counter-attack will be carried out according to the same principles as for the attack, but a definite objective should be fixed for it, and it should never be pressed beyond the forward positions of the defence.

Maxim vi. The one great advantage which the defence possesses is that every move can be thought out and rehearsed beforehand. Every possible line of enemy advance should be reconnoitred and plans worked out for countering them. The possible routes of manœuvre and fire positions on them for each manœuvre company and platoon should also be reconnoitred and marked.

Maxim vii. A counter-attack by any unit smaller than a platoon is rarely effective. Hence fire and not counter assault is the best course for manœuvre sections to adopt.

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PLATE.I

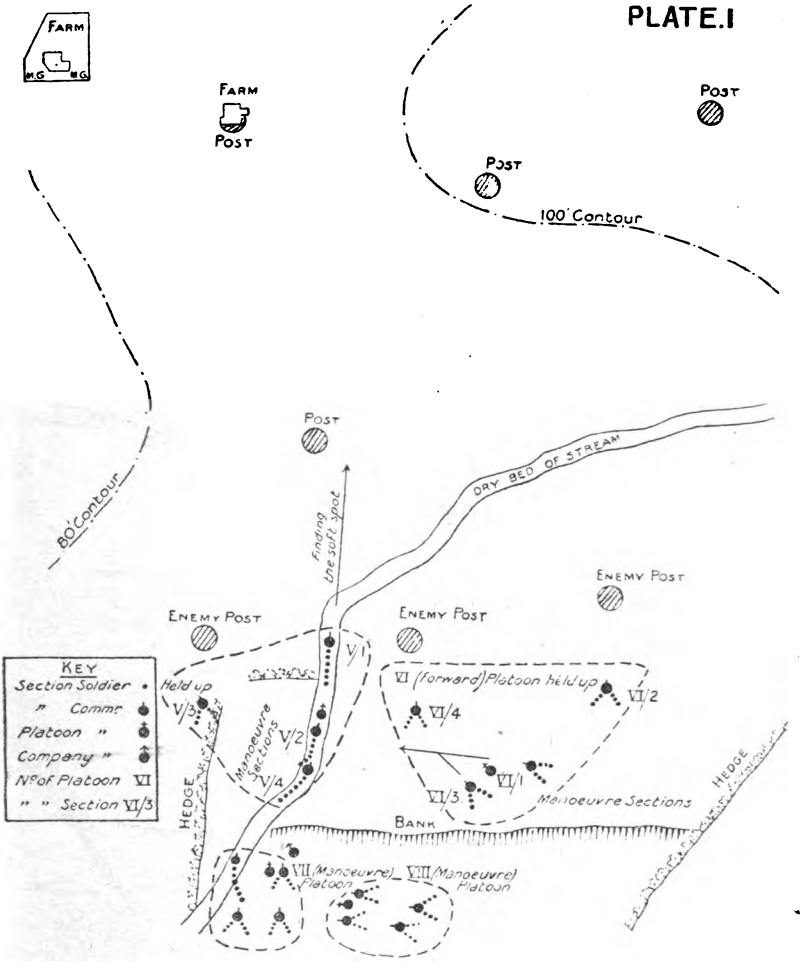

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PLATE.2

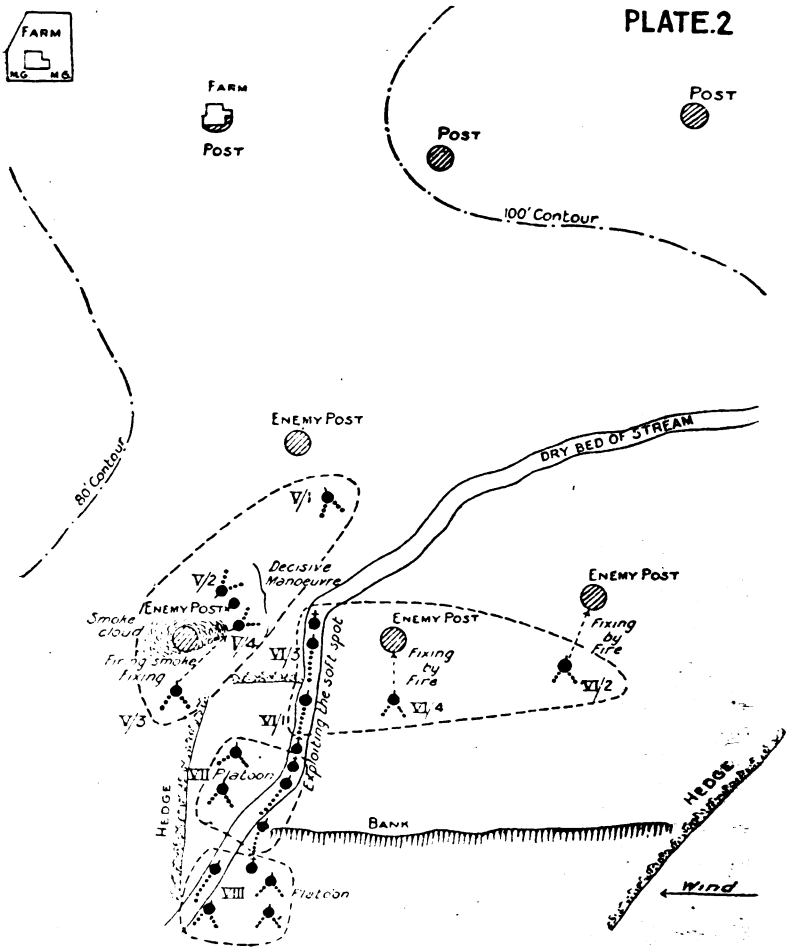

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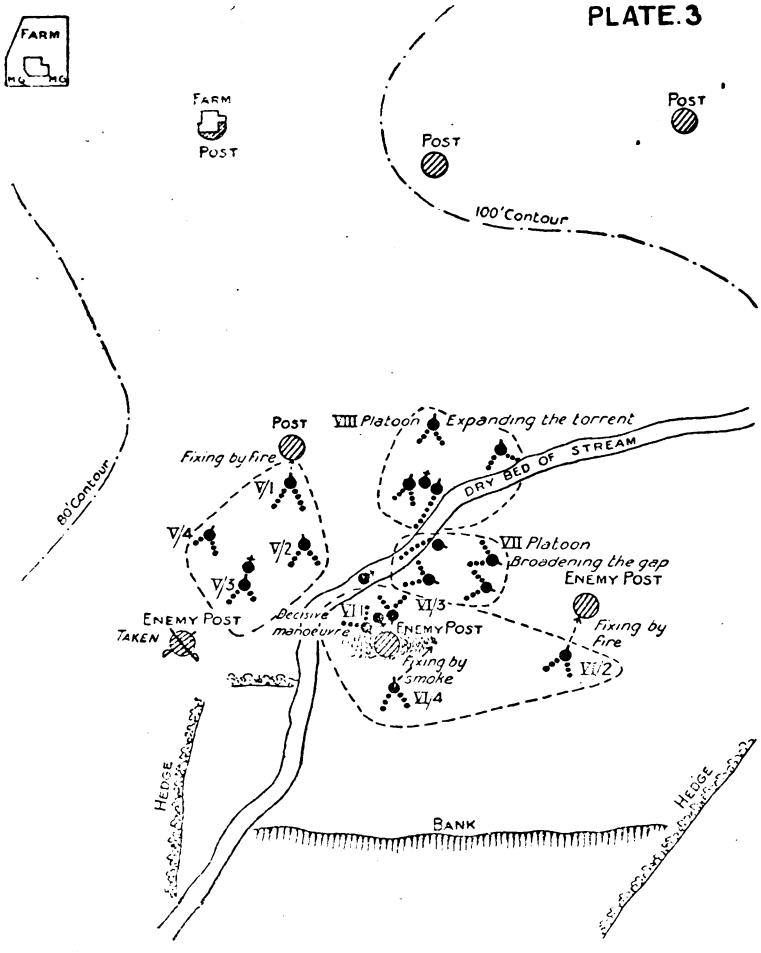
PLATE. 3



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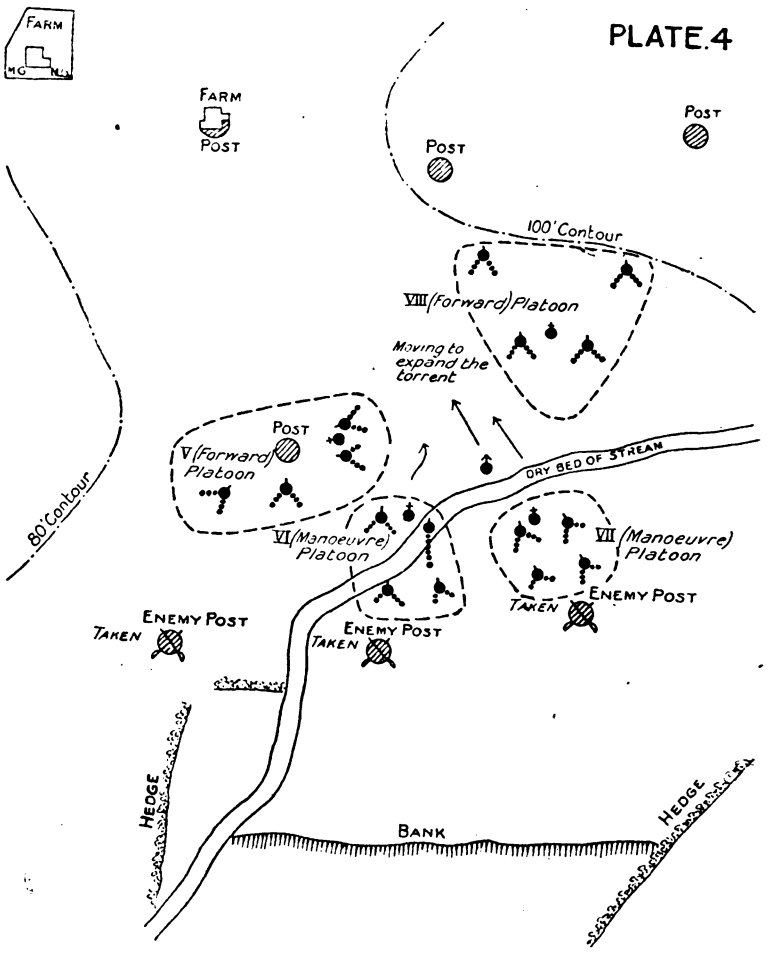

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C (V).—Exploitation.

Exploitation is the counter-offensive when the enemy's attack has failed, and is therefore not true defence.

Outposts.

It should be clear from our analogy of the human tank that outposts *are* simply a temporary form of defence.

Maxim i. When contact with the enemy is unlikely the main consideration is to rest as many troops as possible. Hence units should usually be disposed with only *one* sub-unit forward and three for manœuvre.

Maxim ii. It will suffice, particularly at night, if the main channels of approach are covered by the forward bodies.

Maxim iii. With this reservation the disposition and routine duties of outposts will be similar to those for defence. Only the first stage of consolidation, that of disposition over the ground for observation and resistance, will be needed.

Retirements.

These are simply a mobile defence.

Maxim i. Hence security is the first consideration.

Maxim ii. Retirements should be carried out therefore by a series of leapfrog bounds, the forward body retiring covered by the fire of the manœuvre body to a position behind it, from which, in turn, it can cover the retirement of the manœuvre body. Thus the strain of holding off the enemy will be evenly distributed between forward and manœuvre bodies.

Maxim iii. In flat country zig-zag bounds should be used to avoid the risk that the fire of the covering body may be masked by the retiring body.

Maxim iv. If the enemy presses the retiring body too hard, a sudden counter-attack should be made by the manœuvre body to relieve the pressure.

Summary.

Thus we see that by working out our principles of tactics upwards from the elementary, instead of downwards from the complexities of large operations, we can simplify infantry tactics to a flexible framework of clear principles which are applicable to all forms of action. This frame work provides us with a sound base upon which to build up our practical knowledge of ground and weapons. It has been the hope and aim of the author to create the foundations of a true science of infantry tactics.

The above Lecture has been Published in Pamphlet Form with an Appendix and a Foreword by Lieut.-Gen. Sir I. Maxse, K.C.B., C.V.O., D.S.O., and can be obtained from Messrs. H. Rees, Regent Street, S.W.1, for 2/-.

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INTERNATIONAL COMMUNICATIONS : QUESTIONS AT THE PARIS CONFERENCE AND AFTER.

A LECTURE DELIVERED BY BRIG.-GENERAL H. O. MANCE, C.B., C.M.G., D.S.O., AT THE COMMERCIAL UNIVERSITY OF ROTTERDAM ON 13th DECEMBER, 1920.

IT is necessary that I should preface this paper with the intimation that the opinions expressed therein must be regarded as purely personal and as carrying no official weight whatever.

So much has been done on the subject during the past two years that it will naturally be impossible to cover the whole ground of International Communications in one short paper. I have, therefore, had some difficulty in choosing a course which would avoid on the one hand giving too superficial a summary of the whole field, or on the other hand, too detailed an exposition of any part of it. For those who may desire to study the question in greater detail it may be useful to refer to the Chapter on Communications in Volume II of the *History of the Peace Conference at Paris* produced by the British Institute of International Affairs, which chapter I had the honour of writing, to the Reports of the Communications Section of the Supreme Economic Council dated January 1st and May 1st, 1920, which were circulated at the Financial Conference at Brussels, to the preparatory documents for the first General Communications and Transit Conference of the League of Nations which will take place at Barcelona early in 1921, and to the proceedings of the Assembly of the League on December 8th and 9th.

In reviewing general Communications questions one cannot help being struck with the inadequate recognition, by the generality of people, of the dominating influence of communications on the development of civilization. The poet Kipling had indeed said that transportation is civilization, but prior to the Great War a casual observer might well have formed the opinion that the interest of a large majority of the general public was limited to such questions as the cheapness of railway fares, or the quality of the refreshments at the Railway Buffets. The Great War, however, by the withdrawal or limitation of facilities so unthinkingly enjoyed in the past, has brought home to a far wider circle their dependence on free communications and more particularly on International Communications; hence it was natural that at the very outset of the Peace Conference at Paris a special Technical Commission should be appointed to deal with questions of Communications—Railways,

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Waterways and Ports. To this Commission fourteen States sent technical experts whose close association went far to re-establish and strengthen the spirit of cordial collaboration in international communications questions, which has been so valuable an asset to their successors. This Commission was not called upon to deal with the political aspects of the Peace Treaty but to prescribe the transportation measures necessary to render possible the general intentions of the Treaty and to enable the belligerent Nations to re-establish normal relations.

The situation to be resolved may briefly be summarized as follows :

The provisions of the Congress of Vienna regarding International Waterways, while facilitating the gradual crystalization of certain important principles of international right, had only been partially applied as regards the administrative *régime* of International Rivers ; during the succeeding century the international rivers have greatly increased in number and cover the whole world. Irrigation, reclamation, hydraulic power, fishing and other Water Rights have assumed a rapidly growing importance and have to be taken into account as well as navigation. The development of Canals, Railways, Ports, Telegraphs, Telephones and Mechanical Transport, not to mention flying, had opened up an enormous field which had never been reviewed as a whole from the standpoint of international right. Pre-war international relations regarding communications had been built up haphazard, such general conventional agreements as existed being based rather on the grounds of expediency than on established principles of international right. Moreover, in the demoralization resulting from the war there was no guarantee that after a complete break of five years the pre-war standard of transportation ethics would be recognized.

The specific problems arising out of the Peace Treaties were of great complexity, owing not only to the natural technical difficulties of framing at short notice conditions safeguarding in the future an enlightened *régime* of international communications, but also to the special problems arising out of the vast and simultaneous changes in practically all the frontiers of Europe ; access to the sea had to be assured to the new landlocked, or nearly landlocked States of Austria, Hungary, Poland, and Czecho-Slovakia ; the creation of new States, whose national interests would inevitably tend to a considerable upheaval of the economic conditions obtaining before the war, was likely in many cases to result in fundamental changes in the direction and intensity of international traffic. It was therefore necessary on the one hand to give reasonable time for the new *régime* to crystallize while shielding it, as far as possible, from adverse influences directed to political ends, and on the other hand to minimize the real risk of common economic loss resulting from too sudden changes, by assuring the necessary co-ordination between

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separate parts of previous economic units. Finally, there was the necessity, during the period of re-construction, for safeguarding certain Allied interests from competition and for granting them special temporary facilities, the necessity for which was recognized in Article 23*e* of the Covenant of the League of Nations.

How then was this great task to be approached? In the unanimous opinion of the Ports Waterways and Railways Commission it was necessary to lay down general principles regarding the various means of communications before attempting to deal with specific cases, and for several weeks the Commission concentrated on the consideration of draft General Conventions on Freedom of Transit, on International Rivers and on International and Free Ports. Doubtless the texts of the Treaties could have been improved had it been found possible to proceed further with the consideration of the above General Conventions, and with a General Convention on Railways, but luckily sufficient progress had been made to enable a considerable number of articles to be transferred *en bloc* from the draft Conventions to the Peace Treaties, thereby saving a large amount of discussion and affording important "directives" for many of the other clauses; on the other hand the lack of pre-determined general formulæ on the question of railways undoubtedly added to the difficulty experienced in drafting certain of the Railway Articles in the Treaties. While the work done on General Conventions at the Peace Conference undoubtedly constituted a valuable basis, it is evident that their ultimate conclusion is a matter more appropriate for an international than for an inter-allied body.

A few words on the general procedure adopted at the Peace Conference may be of interest. The Draft General Conventions usually formed the subject of a discussion on general principles, followed by a debate on the various articles which served to bring out, and in many cases to adjust, differences in views of the various Delegates. Small Drafting Committees then gave the Conventions a detailed examination and prepared drafts based on the previous discussions. As regards articles of the Peace Treaties, it was natural that a number of claims should be brought forward in a form which conflicted either with the general principles already adopted, or with the interests of other Allies. As the Members of the Commission got to understand each other's point of view, it was found possible to reconcile, or arrive at an agreement on, all such conflicting claims; gradually it became recognized that deviations from the general principles previously arrived at would only be accepted by the Commission if, and to the extent that, they were proved to be necessary for special needs—reconstruction, access to the sea, etc.—for which exceptional treatment had been reserved. In certain cases after reducing to its simplest expression the object which it was desired to attain by a particular draft article which had been sub-

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mitted, a satisfactory solution, in conformity with the accepted general principles, was arrived at as a result of the labours of informal Sub-Committees of technical experts. When possible, the principle was adopted of making clear the intention of the stipulations, leaving the details to be settled in agreement by the technical administrations concerned, subject to arbitration on any points of difference. The fact that the Commission submitted two reports, covering 64 articles all of which had been unanimously agreed to, may be regarded as a remarkable achievement, and a happy augury for future international relations in matters of transit and communications.

At the stage to which the discussion on general conventions had been carried by the Peace Conference, there appeared to be no intrinsic reason why world-wide Conventions should not be agreed upon to establish the fundamental principles of freedom, equality, and continuity in the international *régime* of transit and waterways and to a large extent in those of ports and railways. The shades of opinions advanced during the discussions varied from complete internationalization on the one hand to repudiation of any proposal which affected the slightest limitation of national sovereignty on the other hand. It had been suggested that owing to the difference in the geographical conditions, there would be difficulties in concluding General Conventions applying the same *régime* to various parts of the world and the discussions on this point brought out the essential difference between questions of international right and questions of international administration. Generally speaking, apart from international rivers where physical considerations may render a certain measure of international administration unavoidable, especially where there are several riparian States, the general trend of opinion was against international administration except in very special cases and then only in virtue of agreements to which the State or States territorially interested are parties. It is hardly necessary to mention that questions of free commercial competition between different routes or transport undertakings are outside the province of General Conventions. A most important development was the general acceptance of the principle of compulsory arbitration through the League of Nations for all disputes arising out of the Peace Treaties on Transportation questions, and the inclusion of the same principle in the draft General Conventions. Transit and transport questions are particularly susceptible to arbitration and it may well be hoped that the experience gained by the successful application of the principle to transportation questions may create a valuable precedent for its extension to other matters.

Time will not admit of an analysis of the whole of the Communications and Transit Articles of the Peace Treaties, and I will therefore concentrate my remarks on the Articles dealing with the various

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international rivers, which are perhaps those of most interest to Holland.

The international rivers dealt with are the Rhine, the Danube, Elbe and Oder and Niemen, with certain of their tributaries either expressly mentioned or included in a general definition in Article 331 of the Treaty of Versailles. With the exception of the Rhine, which was specially dealt with, the above rivers are formally placed under a provisional *régime* prescribed in Articles 332-337, these articles, with the exception of the second paragraph of Article 332, having been taken *en bloc* from the Draft General Convention on international rivers. It was further prescribed in Article 338 that the above provisional *régime* would be replaced in due course by the *régime* prescribed in a General Convention approved by the League of Nations. With the exception (1) of the Rhine-Danube Canal, which may in the future have an altogether special importance in international waterway communications in Central Europe, and (2) of the German portion of the Rhine-Meuse Canal the construction of which was prescribed in the Treaty under certain conditions, no artificial canals other than those for improving the natural navigation of international rivers are affected by these provisions.

It will further be noted that with the exception of the latter part of Article 332 the *régime* prescribed does not impose any obligations which are not equally accepted by all the contracting parties affected and this also applies to the navigation provisions of the Rhine.

As regards administration, the Elbe and the Oder are to be administered by International Commissions and the Niemen may be administered by an International Commission on the request to the League of Nations of any of the riparian States. These River Commissions differ from the Commissions which were prescribed with such limited results by the Congress of Vienna in that provision is made for representatives of non-riparian as well as of the riparian States. The introduction of non-riparian Members on these Commissions has been strongly criticized but was decided after careful consideration to be essential in the general interest of freedom of navigation in order to introduce a check to prevent the strongest riparian State from abusing her predominating influence to the detriment of others. Hence it was naturally essential that no one State should command a clear majority. The functions of the Commission are limited to the practical application of the principles laid down either in Articles 332-337, or in the General Convention, and it must be remembered that the powers of the Commission in each case extend to the territory of at least one of the Allied and Associated Powers.

It is natural in the present state of development of international relations that a State should be disinclined voluntarily to agree to

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any administrative arrangement which tends to limit even indirectly its sovereign powers. I can, however, hardly conceive a less objectionable form of penalty imposed in a Peace Treaty than the institution, in the general interest, of proved methods of international collaboration; this observation, while arising out of the institution of certain river commissions, equally applies to the consequential obligation for the ex-enemy States to accept both the General Conventions which it is hoped will govern International Communications in the near future and also revised regulations regarding the above-mentioned rivers which may be necessitated by such Conventions. This class of obligation was not limited to ex-enemy States in the Treaties as the creation of new States as well as the recognition of mandatory States has generally been subject to the acceptation by the States concerned of obligations to conform to generally accepted international standards in such questions as communications, and in other matters, whereby an enormous advance has been made in the recognition of international as distinguished from national interests. The development of the sanction given to such international interests coupled with the support of a gradually formed world public opinion offers, in my opinion, the surest road to the gradual abolition of war as a method of settling international disputes.

In the case of the Danube there existed already a conspicuous and successful precedent for the working of a Commission with representatives of non-riparian States, and the Danube European Commission was therefore revived with a provisional limitation of Membership to Roumania, Great Britain, France and Italy; at the same time a second Commission was formed for the whole of the international Danube system above the sphere of the European Commission, this second Commission replacing five independent pre-war Administrations. As it was felt that the whole question of the Danube was too complicated to be settled definitely at such short notice, it was arranged that a General Conference of certain Allied and Associated Powers, at which representatives of ex-enemy States would be present, should determine at a later date the permanent statutes of the Danube. This Conference has already commenced its sittings.

As regards the Rhine the situation was complicated by the existence of the Neutral riparian States, Holland and Switzerland. It was important to obtain at least an outline of the views of these two States and valuable statements were made before the Ports Waterways and Railways Commission by Delegations designated by each of these two states. The principal aim in view in this case was the same as that for the other rivers, namely, to assure the greatest possible freedom, equality and continuity of navigation to all the States of the world, but in the special circumstances it was necessary to

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approach the problem in a different way. This was the more necessary as the Rhine had already for many years been governed by the Mannheim Convention, which is an extremely liberal one and needed only certain trifling modifications to bring it into line with the *régime* prescribed for the other rivers. Apart from the above modifications which were inserted as a provisional measure, it was prescribed that the Mannheim Convention should be reviewed and should conform to the General Convention on International Rivers when such General Convention shall have been adopted; the revised act of navigation will be submitted to the states represented on the Central Commission; the necessary negotiations with Holland were to be undertaken by the Allied and Associated Powers. When, however, it came to the question of considering the future administrative *régime* of the Rhine, the question was complicated both by the previous *régime* under which it would have been possible for one riparian State, and that an ex-enemy State, to exercise a clear preponderance of votes, and further by the consequential results of the transfer to France, exclusively, of certain Water-power Rights which would otherwise have been shared with Germany. France obtains the sole right to develop this Water-power subject to Germany receiving half the net value of the power obtained. This latter question is of the same order as a territorial transfer and in no way affects, by itself, the *régime* of navigation, but in view of the fact that exercise of these Water-power Rights would inevitably raise questions of the highest importance affecting the maintenance of free navigation, it was necessary, in conformity with the spirit of the draft General Conventions, that any scheme for the development of Water-power should be reviewed from the point of view of its effect on navigation by a thoroughly representative body whose opinion might be accepted with confidence by both the Water-power and the navigation interests. Hence, after very careful study, a system of votes was arrived at which was considered to give weight in a suitable proportion to the various interests affected by this important question, including the world interests of navigation as represented more particularly by the non-riparian States. It was perhaps inevitable that the question of votes should have attracted attention more from the general point of view than from the point of view of the specific question of Water-power; it is therefore important to note that, except in certain matters mentioned in the Treaty in which Germany is under obligation to confirm the decisions of the Commission, the varying number of votes has a moral rather than a practical significance in view of Article 46 of the Mannheim Convention under which the decisions of the Central Commission are only valid after approval by the respective Governments.

I have limited myself to a *résumé* of the situation regarding the Rhine up to the signature of the Treaty of Peace as the subsequent

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history affects negotiations with Holland which are not yet completed. In the general interest of the development of a liberal *régime* of international communications in which all parties concerned have so pre-eminent an interest, it is earnestly hoped that a solution will not be long deferred. *

An important series of clauses designed to facilitate the resumption of normal conditions is based on the principle of equity in the adjustment of questions such as the redistribution of rolling stock and river craft and installations, resulting from territorial changes. Just as it was necessary that railways in transferred territories should be provided with their complement of rolling stock, so it is necessary to assure to the river ports of transferred territory the proportion of shipping and installations necessary for their traffic. The quantity of shipping and installations to be ceded is to be determined by an American Arbitrator with due regard to the legitimate needs of the interested parties. Holland is interested in that some of the installations to be transferred to France by Germany for the needs of Alsace-Lorraine traffic are situated in Rotterdam. The arrangements for the transfer of craft and rolling stock necessarily present problems of an intricate nature, but thanks to the general principles laid down as a basis for an equitable repartition it is hoped that the Arbitrator and the Commissions appointed for the purpose will arrive at solutions acceptable to all parties.

Among the special features of the Communications clauses of the Treaty it should be noted firstly, as already mentioned, that any disputes arising with regard to the interpretation and application thereof, are to be regulated as provided by the League of Nations, and secondly that a possible revision of many of the Articles is contemplated—in some cases compulsorily, in order to comply with future General Conventions regarding International Waterways, in other cases at the option of the League of Nations after a stated period, or again, by the contracting parties on the recommendation of the League of Nations, in the case of a permanent administrative *régime*. As it was not always possible, notably in certain general articles affecting railways, to separate or even to distinguish between the provision which should govern the permanent relations between the signatories of the Treaty and the stipulations imposing transitory obligations in favour of the Allied and Associated Powers, it was provided that failing revision by the League of Nations (for example, in order to bring certain provisional stipulations into line with the General Conventions subsequently adopted) the stipulations of certain articles can only be claimed after a certain period if reciprocity is accorded in respect of such stipulations.

* NOTE.—These negotiations have since been completed, and the first full session of the new Central Rhine Commission was held at Strassburg on February 25th, 1921.

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The combined product of a number of delegations whose outlook varied with national temperament and circumstances is obviously not an ideal exposition of the views of any one of them. Nevertheless, it is believed that, having regard to the circumstances the verdict of the future will be that the section of the Treaties dealing with transit and communications is a consistent whole which is founded on the principle of the greatest possible freedom of transit and communications; that such derogations of this principle as were admitted to meet temporary conditions are transitory, and that the intentions of the framers are reflected in the stipulations assuring the flexibility necessary for ensuring that the articles should conform in the future with altered conditions, or for eliminating any features which as a result of experience may be generally recognized as being contrary to the spirit of the League of Nations.

At the commencement of the Peace Conference a large number of pressing questions had to be dealt with which did not concern the Treaties of Peace, such as questions of urgent relief in Central Europe and measures for the gradual restoration of normal conditions; it was to deal with this class of questions and to co-ordinate the efforts of the principal Allied and Associated Powers for alleviating the situation both in Allied and Enemy countries, that the Supreme Economic Council was formed in February, 1919. It was at once found that owing to the complete disorganization of communications the re-establishment of normal conditions, or indeed the execution of the relief programmes, was dependent on the re-organization of communications. A Communications Section of the Supreme Economic Council was therefore created as a consultative body to co-ordinate the voluntary efforts of the various Allied powers who were assisting in the re-establishment of normal conditions in Europe. The Section had no executive powers and exercised its functions through local Missions by personal influence and mutual arrangement with the Administrations assisted. It adopted the principle that in view of the serious situation of communications in Central Europe assistance from any quarter was to be welcomed in the general interest; that the functions of the Section were to support and not to supplant the local Administrations, and were to cease as soon as the new local Administrations had both inspired sufficient confidence to enable them to meet their essential requirements through commercial channels, and also had adopted normal international relations. The Section was able to afford material assistance by disinterested technical advice from the specialists constituting their local Missions, by the allocation and transfer of Armistice rolling stock, by arranging for credits for the purchase of urgently needed tools

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and materials, and by acting as intermediary between the different administrations until such time as it was possible for them to establish direct relations.

The Committee for regulating wagon exchange in Central Europe pending the definite allocation of the rolling stock of the old Austro-Hungarian Empire, was created, under the disinterested Presidency of M. Leverve, on the initiative of the Communications Section as an indispensable preliminary for winding up their work.

The Communications Section were recently responsible for convening the technical Conference held at Paris in July last for the improvement of postal, telegraph and wireless communications in Europe and for initiating the rough census of rolling stock in Europe carried out on September 12th. It is evident that the matters dealt with by them were bound to become more and more international in their nature, and arrangements are in operation for handing over the outstanding functions of the Section to the Provisional Communications and Transit Committee of the League of Nations.

The principal difficulty which the Communications Section has had to contend with has been the lack of goodwill between the various States in Central Europe, this in turn being partly due to mutual suspicion pending the uncertainty of the Peace terms and the delay in their ratification. One of the limiting physical factors is undoubtedly the lack of a sufficient supply of coal and a further vital need in each country has been the question of repairs to locomotives and rolling stock. The lack of repair material was to a large extent got over by the credits referred to above, but both locomotive and rolling stock repairs and the output of coal suffered from the general disorganization of labour output. Finally, the complete administrative re-arrangement necessitated by the Treaties involved in places the creation of entirely new administrations for which eligible high officials were lacking, and this presented a handicap which it will greatly redound to the credit of certain States to have overcome.

As soon as the Peace Treaties were disposed of, the question arose as to the further consideration of the Draft General Conventions. On the one hand it was considered that these Conventions would more properly be elaborated by the League of Nations: on the other hand the League of Nations was not even yet in existence and it was important not to lose the advantage of the special knowledge and of the spirit of co-operation acquired by the representatives of the Allied States as a result of some months of close association. In the circumstances the French Government took the initiative by convening a Commission of Enquiry on Freedom of Communications

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and Transit to which certain Neutral States (including Holland) as well as the Allied Powers were invited to send representatives; it was clearly stipulated that these representatives would not bind their Governments in any way, the object of the Commission being to prepare the ground for the League of Nations. That this object was attained was evinced by the fact that the Commission of Enquiry was invited in February last to act as the Provisional Communications and Transit Committee of the League of Nations, in which capacity it has drafted proposals for the Permanent Communications and Transit Organization of the League of Nations, and Conventions on Freedom of Transit, International Waterways, on the International *Régime* of Railways, together with a resolution relating to an International *Régime* for certain Ports. These draft proposals, which were the result of several months' hard work, will be submitted to the forthcoming General Communications and Transit Conference which is to be held at Barcelona not many weeks hence. The adoption of the Conventions by the Conference would constitute an outstanding land-mark in the development of international relations; the conventions, once adopted, will be binding on those States which ratify the same, including several States which have already contracted to adhere to them in the various Treaties resulting from the War.

Time will only admit of the briefest of observations with reference to the contents of the various Draft Conventions.

Speaking generally, these Draft Conventions have only been rendered feasible by the creation of an advisory body in the organization of the League of Nations. The existence of such a body renders it possible to utilize certain essential though very general expressions such as "legitimate," "reasonable," "valid reason." But for the existence of an advisory body these expressions could not be invariably relied on to convey a definite meaning, but thanks to it they can in every particular case indicate clearly the intention of the Conventions with regard to their interpretation.

The Freedom of Transit Draft Convention is the embodiment of a principle of vital importance to civilization, and this principle is perhaps one of the highest conceptions which has been crystalized as the result of the war. Divested of all extraneous additions, the principle is that every country should enjoy the same material conditions of communications with any other country or with the sea across the territory of one or more intervening states as it would have enjoyed if such intervening State or States did not exist. These conditions should not depend on the nationality, origin, importation, starting point or ownership of the traffic or means of communications or conveyance.

Among the obstacles to the complete adoption of the principle is the practice which has grown up especially in countries with State

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railways, of using railway communications as an instrument of fiscal policy. The proposal was indeed made that every country should undertake to purge its railway policy of all protectionist factors while allowing full liberty of commercial competition between various lines. It was contended that differential railway rates based on fiscal considerations interfered with the natural working of transport undertakings, vitiated indirectly custom *régimes* and disturbed the application of commercial Treaties. The time was not, however, ripe for the general acceptance of this doctrine which, however, is essential if the principle of freedom of transit is ultimately to be assured in its entirety.

Similar considerations will affect the future scope of any Railway Conventions affecting international traffic other than transit traffic. For the present it has only been found possible in the Draft Railway General Convention to lay down certain guiding motives which should regulate the conclusion of special Conventions for dealing with various matters, to forbid discrimination in tariffs based on the nationality of passengers, on the ownership or commercial origin of goods, or upon the flag or ownership of the vessels which have been or are to be employed either before or after their transport by rail, and to apply universally the principle laid down in the Berne Convention preventing discrimination by rebates in favour of individuals. Perhaps the most important article is that which brings international disputes on railway questions under the machinery of the League of Nations.

As regards the Draft General Convention for International Waterways, greater difficulties were found in drafting a world-wide convention than in the case of the other conventions. I propose only to draw attention to a few out of many points of interest which might have been mentioned. Reference has already been made to the necessity for taking account of other uses than navigation, for the water of international rivers and in the Draft Convention even the extreme case has been provided for under which the unanimous decision of all of the States which are riparians of an international waterway, or represented on the International Commission if there is one for such Waterway, might result in the total suppression of the use of the river for navigation. Such a case may well arise among the Waterways which would technically be defined as international under the Draft General Convention.

The obligation on each riparian State to maintain a waterway in its existing condition as prescribed by the Congress of Vienna has been maintained subject, if necessary, to an allocation of expenses between the States concerned proportionate to their respective interest in the said work, always provided that special agreements do not exist on the matter. An innovation that has been proposed is that any interested State may require the execution of works of

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improvement to the navigation at its own expense provided that these works would not prejudice the legitimate interests, other than those of navigation, of a State territorially concerned.

One of the few instances in which the Provisional Committee did not arrive at an agreement was on the question of *petit cabotage* or local transport on international rivers between the ports of the same State and this question was therefore excluded from the scope of the Draft Convention. The matter does not affect the Rhine where absolute freedom of *petit cabotage* is already accorded to all the nations.

The definition of an International Waterway has provoked lengthy discussions. The canalization of the head waters of many rivers renders it necessary to define more closely the meaning of the word "navigable" in the river enactments of the Congress of Vienna, and the expression "naturally accessible from the sea" was adopted to this end. As an agreement could not be obtained to include in the definition the purely national tributaries of international rivers the resulting definition is somewhat complex and can only be understood by reference to a diagram.

It is important to note that in a limited degree the Draft Preamble extends to national waterways certain principles and stipulations referred to in the convention without, however, subjecting the disputes arising therefrom to the jurisdiction of the League of Nations.

An ideal worth striving for would be the establishment of a *régime* of free communication on the great waterways uniting Western Europe with Northern and South-Eastern Europe corresponding to the liberal *régime* which now prevails on all Dutch waterways. The attainment of this and similar ideals will depend on the League of Nations Communications and Transit Organization establishing itself in the general confidence to such an extent that uniformity of *régime* can be achieved through the use of this organization for conciliating disputes.

Happily we are not now in the dark when referring to this League of Nations Communications and Transit Organization, as it was outlined by the Council of the League of Nations in their resolution of the 19th May, and confirmed with certain modifications by the Assembly on December 9th, while the detailed scheme has been worked out by the Provisional Committee and will be submitted for the approval of the forthcoming General Conference. Briefly, the proposed organization consists of General Conferences to be summoned when necessary by the Council, comprising representatives of all the members of the League with an Advisory Committee, which would prepare for sessions of the General Conference and take any necessary steps to watch over the execution of its decisions. The Advisory Committee would also act as a consultative and technical

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organ to the Council of the League, and would have important functions as regards the conciliation of disputes arising out of the Treaties of Peace and the General Conventions, the ultimate appeal being to the Permanent Court of International Justice which alone would have power to impose or authorize any penalties on defaulting states. The Committee is intended to represent the members of the League as a whole, and its members therefore would not represent or receive instructions from the Governments by which they were nominated, and could not be removed during their tenure of office. The selection of States to designate members of the Committee was naturally the object of a considerable discussion. The total number of members of the committee is not to exceed one-third of the number of members of the League. It is proposed that each state permanently represented on the Council of the League should nominate one member, the other members being chosen by election at the Conference. The tenure of office will be four years and it is suggested that half the elected members should retire every two years. In order to obtain a certain rotation only half of the States which nominated the retiring members will be eligible for re-election.

It is hoped that this solution, which was at once the simplest and fairest which could be devised and was agreed to unanimously by the Provisional Committee, will meet with the approval of the General Conference.

It will, I suppose, be generally agreed that the improvement of communications, by rendering possible centralized administration, by facilitating the exchange of ideas and latterly by binding different parts of a country closely together by common economic interests, has largely contributed to the consolidation of peoples up to the limits of nationality. In the case of the United States of America, where development of communications proceeded simultaneously with the settlement of peoples migrating westwards from Europe, it has recently been suggested by Lord Ashfield, in his presidential address to the British Institute of Transport, that inter-communication was the principal factor in preventing the establishment of separate nationalities such as resulted in Europe from the earlier migrations from the East. It is pertinent to ask how far these same factors may tend to operate as between nations, and how far unity of interest brought about by improved communications may gradually overcome the further barrier of nationality and lead to common regulation of international relations in such a way as to prevent the action of any one nation interfering with the freedom of communications of the rest of the world. It is evident that any steps which it may be found possible to take in this direction will tend towards the elimination of many potential causes of friction arising from the existence of national frontiers. This fact is recognized by the framers of the Covenant of the League of Nations in Article 23*e* in which the Member States

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undertake to make provision to secure and maintain freedom of Communications and Transit and equitable treatment for the commerce of all Members of the League.

Too much prominence has perhaps been given to the political aspects of the League of Nations and to its responsibilities as a definitely established organ of international relations and not enough emphasis has been laid on the necessity for the League itself to build up from its very foundations the solid supports of international opinion and international interests necessary for such a superstructure of responsibility. One of the most important of these supports, and perhaps the one which can first be taken in hand, is the creation of a more liberal *régime* in questions of communications and transit. It has been the object of this brief *résumé* to review the development of the measures which have been taken during the last two years to achieve this end, culminating in the passing only a few days ago of the resolution of the Assembly of the League of Nations which confirmed the creation of a Communications and Transit Organization of the League of Nations, and enjoined the convocation of a General Conference at Barcelona at an early date to elaborate the details of such organization and to consider the Draft General Conventions to which I have alluded. Communications will, in the future as in the past, lead the way in the development of international collaboration. Without such collaboration the development of communications in their latest form—by air and by wireless—would be strangled in its infancy. Without such collaboration the economic reconstruction of Central Europe would seem an impossible task. It is not too much to say that the success of the League of Nations itself will depend in a large measure on the Freedom of Communications and Transit. This fact alone confers, both on the transportation experts of all countries and on the principal users of international transportation, a great opportunity and a great responsibility at the present juncture when so much depends on a spontaneous impulsion in the various fields of activity towards applying the spirit of the Covenant in the regulation of international relations.

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BOOKS ON CIVIL ENGINEERING.

(Continued from February R.E. Journal).

ERRATA.

It is regretted that the prices given in the portions of this list already published in Jan. and Feb. numbers *R.E.J.*, in many cases were wrongly stated. Most of the books have now increased in cost about 25 per cent. The prices given below are correct.

10. STRUCTURAL STEEL AND STEEL BRIDGES.

ENGINEERING CONSTRUCTION IN STEEL AND TIMBER.—By W. H. Warren, M. Inst. C.E., Challis Professor of Engineering, University of Sydney. Published by Longmans Green and Co. Part I., 30/-. Part II., in the Press.

Chapter I., Stress, Strain, Working Stresses; Properties of Steel. Chapter II., Timber and its Properties. Chapter III., Determination of the Stresses in Structures. Chapter IV., Bending Moments and Shearing Stresses, Influence Lines. Chapter V., Moments of Resistance and Intensity of Shearing Stresses in Beams. Chapter VI., Bridges and Viaducts of Small Span. Chapter VII., Examples of Graphical Statics. Chapter VIII., Braced Girders with Parallel Chords. Chapter IX., Bowstring and other Trusses. Chapter X., Slope and Deflection of Beams. Chapter XI., Continuous and Cantilever Bridges. Chapter XII., Strength of Columns. Chapter XIII., Riveted Joints, Pins and Eye-Bars in Bridges, Timber Joints. Chapter XIV., Wind Pressures, etc. Chapter XV., Stresses in Braced Piers. Chapter XVI., Approximate Weights of Girders and Trusses, Live Loads, Concentrated Wheel Loads. Chapter XVII., Plate Web Girder Bridges. Chapter XVIII., Pratt Truss Bridges. Chapter XIX., Design of a Parker Truss Bridge for a Single Line of Railway. Chapter XX., Swing Bridges. Chapter XXI., Arched and Suspension Bridges.

THE DESIGN OF MILL BUILDINGS AND THE CALCULATION OF STRESSES IN FRAMED STRUCTURES.—By M. L. Ketchum, C.E., Professor of Civil Engineering, Colorado University, Consulting Engineer. Published by the Engineering News Publishing Co., New York. 1 vol.; 8vo.; 3rd. edition; 1913. 25/-

Part I.—Loads. Chapters I.—IV., Dead, Snow, Wind, and Miscellaneous Loads.

Part II.—Stresses. Chapter V., Graphic Statics. Chapter VI., Stresses in Framed Structures. Chapter VII., Stresses in Simple Roof Trusses. Chapters VIII.—IX., Beams. Chapter X., Stresses in Bridge Trusses. Chapter XI., Stresses in Transverse Bent. Chapter XII., Stresses in Portals. Chapter XIII., Stresses in a Three-Ringed Arch. Chapter XIV., Stresses in a Two-Hinged Arch. Chapter XV., Combined and Eccentric Stresses. Chapter XVI., Graphic Calculation of Deflection in Beams.

Part III.—Design of Mill Buildings. Chapter XVI., General Design. Chapter XVII., Framework. Chapter XVIII., Corrugated Steel. Chapter XIX., Roof Coverings. Chapter XX., Side Walls and Masonry Walls. Chapter XXI., Foundations. Chapter XXII., Floors. Chapter XXIII., Windows and Skylights. Chapter XXIV., Ventilators. Chapter XXV., Doors. Chapter XXVI., Shop Drawings and Rules. Chapter XXVII., Paints and Painting. Chapter XXVIII., Estimates of Weight and Cost.

Part IV.—Miscellaneous Structures. Description of various Buildings, Specifications, Problems in Graphic Statics and Calculations of Stresses.

"The book is intended to provide a short course in the calculation of stresses in framed structures and to give a brief discussion of steel mill construction. It is meant to supplement the elementary books on stresses on the one hand and the more elaborate treatises on bridge design on the other. Much of the matter will apply equally well to all classes of steel frame construction." The author has a large consulting practice and considerable teaching experience. The book is well illustrated and there are several worked out examples.

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THE THEORY AND PRACTICE OF MODERN FRAMED STRUCTURES.—Designed for the use of Schools, and for Engineers in Professional Practice. By the late J. B. Johnson, C.E.; C. W. Bryan, C.E.; Chief Engineer of the American Bridge Company; and F. E. Turneaure, C.E., Dean of the College of Mechanics and Engineering, University of Winconsin. Ninth edition re-written by F. E. Turneaure and W. S. Kinne, Assistant Professor of Structural Engineering, University of Wisconsin.

Published by Wiley and Sons, New York (Chapman and Hall, London) 3 vols.,; 8vo. I., 1914, 21/-. II., 1911, 27/6. III., 1916, 27/6.

Part I.—Simple Structures. Chapter I., Definitions and Historical Development. Chapter II., Elements of the Analysis of Framed Structures. Chapter III., Analysis' of Roof Trusses. Chapter IV., Analysis of Roof Trusses for Uniform Loads. Chapter V., Analysis of Bridge Trusses for Concentrated Loads. Chapter VI., Lateral Trusses, Trestles, and Towers. Chapter VII., Deflection of Structures and Stresses in Redundant Members.

Part II.—Statistically indeterminate Structures and Secondary Stresses. Chapter I., Continuous Girders. Chapter II., Swing Bridges. Chapter III., Cantilever Bridges. Chapter IV., Arch Bridges. Chapter V., Suspension Bridges. Chapter VI., Miscellaneous Problems in Statically Indeterminate Structures. Chapter VII., Secondary Stresses.

Part III.—Design. Chapter I., Styles of Structures and Determining Conditions. Chapter II., Working Stresses—Tension Members. Chapter III., Compression Members. Chapter IV., Combined Direct and Bending Stresses. Secondary Stresses. Chapter V., Riveted Joints. Chapter VI., Plate Girder Bridges. Chapter VII., Design of Truss Bridges. Chapter VIII., Design of a Pin-Connected Railway Bridge. Chapter IX., Riveted Trusses. Chapter X., Design of a Riveted Highway Bridge. Chapter XI., Design of Steel Roof Trusses.

Appendix A.—General Specifications for Steel Railway Bridges.

Appendix B.—Tables and Standards.

Appendix C.—Unsymmetrical Bending.

This is the standard advanced text book and reference work on the subject in the United States. Though it deals with American practice it is about the best book obtainable either here or in the States.

BRIDGE ENGINEERING.—By J. A. L. Waddell, C.E., D.Sc. Published by Wiley and Sons, New York (Chapman and Hall, London). 2 vols.; 8vo.; 1916. 66/-.

Volume I.—Chapter I., Evolution of Bridge Engineering. Chapter II., The Bridge Specialist. Chapter III., Ordinary Materials of Bridge Construction. Chapter IV., Alloy Steels in Bridge Work. Chapter V., Dead Loads. Chapter VI., Live Loads. Chapter VII., Impact Loads. Chapter VIII., Centrifugal Force and Other Effects of Track Curvature. Chapter IX., Wind, Vibration, and Traction Loads. Chapter X., Methods of Stress Computation. Chapter XI., Secondary Temperature and Indetermediate Stresses. Chapter XII., Deflections. Chapter XIII., Combination of Stresses. Chapter XIV., Intensities of Working Stresses. Chapter XV., First Principles of Designing. Chapter XVI., Detailing in General. Chapter XVII., Shopwork as affecting Bridge Design. Chapter XVIII., Classes of Traffic and Provision Therefor. Chapter XIX., Floors and Floor Systems. Chapter XX., Laterals and Sway Bracing. Chapter XXI., Plate Girder and Rolled I Beam Bridges. Chapter XXII., Simple Truss Bridges. Chapter XXIII., Trestles, Viaduct, and Bridge Approaches. Chapter XXIV., Elevated Railroads. Chapter XXV., Cantilever Bridges. Chapter XXVI., Arch Bridges. Chapter XXVII., Suspension Bridges. Chapter XXVIII., Movable Bridges in General. Chapter XXIX., Swing Bridges. Chapter XXX., Bascule Bridges. Chapter XXXI., Vertical Lift Bridges. Chapter XXXII., Riveted *versus* Pin-Connected Trusses. Chapter XXXIII., Dimensioning for Camber. Chapter XXXIV., Protection of Metal Work. Chapter XXXV., Wooden Bridges and Trestles. Chapter XXXVI., Draw Bridges and Protection. Chapter XXXVII., Reinforced Concrete Bridges. Chapter XXXVIII., Foundations in General. Chapter XXXIX., Cofferdams. Chapter XL., Open Dredging Process. Chapter XLI., Pneumatic Process. Chapter XLII., Piles and Pile Driving. Chapter XLIII., Piers, Pedestals, Abutments, Retaining Walls and Culverts. Chapter XLIV., Shore Protection and Mattress Work.

Volume II.—Chapter XLV., Expedients in Design and Construction. Chapter XLVI., Data required for designing Bridges, Trestles, and Viaducts. Chapter XLVII., Locating of Bridges and Preliminary Surveys. Chapter XLVIII., Borings. Chapter XLIX., Determination of Waterways. Chapter L., Requirements of the U.S. Government for Bridging Navigable Waters. Chapter LI., Hydrographic Surveys for the Bridging of Navigable Waters. Chapter LII., Æsthetics in Design. Chapter LIII., True Economy in Design. Chapter LIV., Determination of Lay-Outs. Chapter LV., Weights of Steel Superstructures. Chapter LVI., Quantities for Piers, Pedestals, Abutments, Retaining Walls, and Reinforced Concrete Bridges. Chapter LVII., Estimates. Chapter LVIII., Office Practice. Chapter LIX., Inspection of

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Materials and Workmanship. Chapter LX., Triangulation. Chapter LXI., Engineering of Construction. Chapter LXII., Erection and False-Work. Chapter LXIII., Maintenance of Traffic. Chapter LXIV., Bridge Examination. Chapter LXV., Reconstruction, Maintenance, and Repair of Existing Bridges. Chapter LXVI., Status of Highway Bridge Building. Chapter LXVII., Bridge Failures and their Lessons. Chapter LXVIII., Specifications in General. Chapter LXIX., Contracts. Chapter LXX., Reports. Chapter LXXI., Administration of Construction. Chapter LXXII., Arbitration. Chapter LXXIII., Promotion of Bridge Projects. Chapter LXXIV., Bridge Engineering Fees. Chapter LXXV., Some Business Features of Bridge Engineering. Chapter LXXVI., Responsibility of the Bridge Engineer. Chapter LXXVII., Ethics of Bridge Engineering. Chapter LXXVIII., General Specifications Governing the Design of Superstructure of Bridges, Trestles, Viaducts, and Elevated Railroads. Chapter LXXIX., General Specifications for Manufacture and Erection of Superstructure, Substructure, and Approaches, etc. Chapter LXXX., Glossary of Terms (243 pp.), Index (224 pp.).

This is a very valuable book, and well worth reading even by other than bridge engineers, for many of its chapters are interesting essays in themselves. The book is written in an almost conversational style, with many touches of personal experience which make it very readable. The author, who is a well known American consulting engineer, states his aim to be " to give to his readers, concerning every branch of bridge work, all the information he has been able to accumulate during a practice of 40 years. Nothing of any value has been omitted, except such matter as can readily be obtained from other books, because he has never been a believer in the pseudo-economic idea that what has cost so much labour and money to discover and record should be utilised only for one's personal gain. On that account there appear for the first time in print all the diagrams of weights of metals, quantities of masonry costs of construction, economic functions, etc., that this book contains."

The book has been very favourably received. It contains 2,200 pages, including a useful glossary of 243 pages, a full index, and very many plans, diagrams, and tables.

11. TIMBER STRUCTURES.

STRUCTURAL DETAILS: ELEMENTS OF DESIGN OF TIMBER FRAMING.—By H. S. Jacoby, Professor of Bridge Engineering, Cornell University. Published by Wiley and Sons, New York. 1 vol.; 8vo.; 1914. 20/-.

Chapter I., Fastenings. Chapter II., Joints. Chapter III., Wooden Beams and Columns. Chapter IV., Wooden Roof Trusses. Chapter V., Examples of Framing in Practice. Chapter VI., Timber Tests and Working Stresses.

A very useful book on the designing of timber work, with much information on the strength of nails and bolts and the strength of joints. Well illustrated with dimensioned drawings. The book is frequently quoted in the United States.

TIMBER FRAMING.—By H. D. Dewell, Assoc. M. Amer. S.C.E., Chief Structural Engineer for the Panama-Pacific International Exposition. Published by Dewey Publishing Co., San Francisco (D. Van Nostrand and Co., New York). I vol. 8vo.; 1917. 14/6.

Chapter I., Introduction. Chapter II., Mill and Yard Specifications, Grading Rules. Chapter III., Working Stresses. Chapter IV., Washers and Pins; Compression on Surfaces Inclined to the Direction of the Fibres; Resistance of Wood to Metal Pins; Sheer Pin Joints. Chapter V., Spiked, Screwed, and Bolted Joints; Laterial Resistance of Spikes and Nails, Common Wood Screws, Lag Screws, and Bolts. Chapter VI., End Joints. Chapter VII., Intermediate Joints. Chapter VIII., Tension and Compression Splices. Chapter IX., Main Members of Trusses, Compression Chords and Struts, Laminated Truss Chords, Timber Tension Member, Tension Rods. Chapter X., Bracing Trusses; Details of Howe Roof Truss, Lattice Trusses, Truss Connections to Posts. Chapter XI., Theory of Columns; Tests of Timber Columns. Chapter XII., Column Splices and Girder Connections; Floors; Joists; Joist Hangers; Mill Construction. Chapter XIII., Foundations. Chapter XIV., Miscellaneous Structures. Chapter XV., Wind Pressure; Working Drawings. Chapter XVI., Specifications for Timber Framing.

An up-to-date book treating fully and practically a subject which is hardly discussed at all in other books, with the exception of the previous one by H. S. Jacoby. The author has had eleven years' experience of timber work on a large scale.

12. HYDRAULICS AND WATER SUPPLY.

HYDRAULICS.—By F. C. Lea. Published by Edward Arnold, 1908. Price 18/-.

Chapter I., Fluids at Rest. Chapter II., Floating Bodies. Chapter III., Fluids in Motion. Chapter IV., Flow of Water through Orifices and over Weirs. Chapter V., Flow through Pipes. Chapter VI., Flow in Open Channels. Chapter VII., Gauging the Flow of Water. Chapter VIII., Impact of Water on Vanes. Chapter IX., Water Wheels and Turbines. Chapter X., Pumps. Chapter XI., Hydraulic

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Machines. Chapter XII., Resistance to the Motion of Bodies in Water. Chapter XIII., Stream Line Motion.

This book deals with the subject in a comprehensive manner. To assist the engineer in the choice of a formula for the flow of water in pipes and channels, some attention is given to the historical development of the various formulæ and particulars of the data from which the constants were determined. The whole subject is treated clearly and the book is thoroughly recommended.

WATERWORKS DISTRIBUTION.—By J. A. McPherson. Published by B. T. Batsford 2nd edition. Price 7/6.

Chapter I., General arrangement of Supply to district of distribution. Chapter II. Notes upon System of Distribution. Chapter III., Details of Method of Laying Out Distributing Mains. Chapter IV., Pipes and Fittings upon Distributing System. Chapter V., Meters and Measurement of Water, and regulating and recording Apparatus.

This is a small handbook which gives good information on the supply of water to cities and towns. It is well illustrated.

MODERN METHODS OF WATER PURIFICATION.—By J. Don and J. Chisholm. Published by Edward Arnold, 1913. Price 16/-.

Chapter I., Introductory. Chapter II., Sources of Supply. Chapter III., Storage. Chapter IV., Construction of Reservoirs and care of Filtered Water. Chapter V., Sand-Filtration. Chapter VI., Management of Sand-Filters. Chapter VII., Mechanical Filters. Chapter VIII., Purification of Ozone. Chapter IX., Water-Softening and Household Appliances. Chapters X. and XI., The Testing of Water. Chapters XII. and XIII., The Problems of Distribution. Chapter XIV., Recent Advances in Sterilization.

This is an up-to-date book giving complete information. It is well illustrated and contains a Bibliography and an Appendix of useful tables.

SMALL WATER SUPPLIES.—By F. Noel Taylor. Published by B. T. Batsford, 1911. Price 7/6.

Chapter I. Properties of Water and Sources of Supply. Chapter II., Wells and Well Sinking. Chapter III., Flow of Water in Channels and Pipes. Chapter IV., Pumping Waters. Chapter V., Storage and Distribution.

This is a practical little work and is intended to give the information needed for planning supplies for estates and country property. For this reason, it will be useful to the engineer who has to arrange for supplies to a small community, although much of the information given is very elementary. A large portion of the book is devoted to pumping apparatus. There is good information on the measurement of the flow of small streams by means of notches.

13. DRAINAGE AND SEWAGE DISPOSAL.

SANITARY ENGINEERING.—By Col. E. C. S. Moore. Revised by E. J. Silcock. Published by B. T. Batsford, 1909. Price £2-4-0. O.P., new edition in preparation.

Volume I.—Chapter I., Conservancy Systems. Chapter II., Sewerage. Chapter III., Sewage Lifting. Chapter IV., Construction and Materials. Chapter V., The Flow of Liquid in Pipes and Open Channels. Chapter VI., Hydraulic memoranda and Tables. Chapter VII., Application of Formulæ. Chapter VIII., Sewer and Drain Ventilation. Chapter IX., Traps. Chapter X., Apparatus—Latrines and w.c.'s. Chapter XI., Apparatus—Urinals, Lavatory Fitments, etc.

Volume II.—Chapter XII., Surface Water Collection. Chapter XIII., Subsoil Drainage. Chapter XIV., Sanitary Notes (Drain Testing, Disinfection, etc.). Chapter XV., Sewage Disposal.—The Problem. Chapter XVI., Sewage Disposal.—Methods of Treatment. Chapter XVII., Sewage Disposal.—Artificial Bacteria Methods. Chapter XVIII., Sewage Disposal.—Sludge. Chapter XIX., Description of existing sewage purification works. Chapter XX., Reports of the Royal Commission on Sewage, and requirements of the Local Government Board. Chapter XXI., Destructors. Chapter XXII., Construction of Chimney Shafts for Destructors.

Appendix I.—Trade Effluents.

Appendix II.—Sewage Fungus.

Appendix III.—Local Government Board Requirements with respect to Sewerage and Sewage Disposal (Revised 1909).

A comprensive book which is very well illustrated. It is provided with a good index and is thoroughly recommended.

It is not, of course, sufficiently modern to include the Activated Sludge process of Purification.

14. ROADS.

MODERN ROADS.—By Percy Boulnois. Chairman of the Council of the Roads Improvement Association. London. Published by Edward Arnold, 1919. 16/-.

Chapter I., Effects of great increase of heavy traffic since 1907. Formation of, and activites of the Road Board. Chapter II., Traffic Statistics. Questions brought

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to the fore by the evergrowing use of self-propelled vehicles, such as best widths, gradients and camber. Chapter III., Water-bound Macadam Roads. Suitable Materials and Tests. Types of Rollers. Specifications and Instructions issued by Road Board. Standing Orders for Road Gangers. British Standard Specification for Broken Stone. Chapter IV., Tar treatment of Surfaces. Specifications and Instructions for Surface Tarring. Tar Spraying Machines. Specifications for Tar. Chapter V., Bituminous Roads. Specifications for "Pitch Grouting." Reports on Trials of different Methods of Construction. Various Patent Materials and Processes. Chapter VI., Bituminous Carpets or Asphalted Surfaces. Various Specifications. Chapter VII., Waves and corrugations. Opinions of Different Authorities as to their cause. Chapter VIII., Paved Streets. Granite Setts and Wood Blocks. Rock Asphalte. Brick Paving. Chapter IX., Concrete Roads. Pros and Cons. Specifications for Materials and Processes. Reports on various Trials. Chapter X., Slippery Streets. Cause and Prevention of Skidding.

The majority of books on Modern Road Construction are from the pens of American writers. The author claims to be the first writer on current English practice.

CONCRETE ROADS.—Published by "Concrete Publications, Ltd." Price 8/-. Chapter I., Concrete Roads in the U.K. (Metropolitan Roads). Chapter II., Concrete Roads in the U.K. (Provincial Roads). Chapter III., Concrete Roads in Industrial Wales and Military Camps. Chapter IV., Concrete Roads in other countries. Chapter V., The growth of Concrete Roads in the U.S.A. Chapter VI., Mechanical devices for making Concrete Roads. Chapter VII., Concrete Curbing. Chapter VIII., Specifications. Chapter IX., The use of Concrete for Road Accessories. The book is well illustrated with diagrams and reproductions of photographs illustrating various roads during and after construction and is well worth studying. Chapters I., II., III., and IV. give useful and detailed information of various roads of plain and reinforced concrete, showing the method of construction, cut, nature of traffic and the resultant wear. Chapter VI. has description and illustration of labour-saving machinery, for excavation, grading, tamping, concrete mixing and depositing, etc. Chapter IX., deals with accessories such as culverts, pipes, fence and gate posts, telegraph and lamp posts, etc., in concrete.

TEXT BOOK ON HIGHWAY ENGINEERING.—By Arthur H. Blanchard, C.E.A.M., Professor of Highway Engineering, Columbia University, New York, and Henry B. Drowne, C.E. Instructor at above University. Published by Chapman and Hall, 1914. Price 27/6.

A book for Instructor and Student.

Chapter I., Historical Review. Chapter II., Location. General considerations of Foundations, Drainage, Widths, etc. Traffic and Censuses. Chapter III., Surveying and Mapping. Organization and duties of Survey Party. Preparation of Plans and Profiles. Chapter IV., Design. Layout of New Townships. Effects of Traffic on Design. Suitable Widths and Grades. Formulæ for Camber. Estimates of Earthwork. Chapter V., Drainage. Subsoil Drainage. Side Ditches and Gutters. Culverts and Catchbasins. Chapter VI., Foundations. Classification of Soils. Artificial Foundations. Foundations of broken Stone, and Concrete. Chapter VII., Earth and Sand Clay Roads. Use of Ploughs, Scrapers and Drags. Special Grading Machines. Maintenance. Chapter VIII., Gravel Roads. Requisite Qualities of Materials. Specifications. Methods of Construction. Chapter IX., Broken Stone Roads. Classification of Rocks. Tests for Road Metal. Quarrying—Drilling, Blasting and Crushing. Description of Process of Construction. Maintenance—Causes of Wear. Implements and Machines. Chapter X., Bituminous Materials. Asphalts and Rock Asphalts. Manufacture of Tar. Tests for Bituminous Materials. Chapter XI., Dust Prevention by Palliatives. Water, Calcium Chloride, Light Oils. Chapter XII., Bituminous Surfaces. Preparation of Road Surface and Application of Bituminous Materials. Mechanical Distributors. Advantages and Disadvantages of Bituminous Surfaces. Causes of Failure. Chapter XIII., Bituminous Macadam Specifications for Asphalte Methods of Construction. Pros and Cons. Maintenance. Causes of Failure. Chapter XIV., Bituminous Concrete. Specifications for Bituminous Cement. Methods of Construction. Various Specifications for Construction. Various Patent Materials and Processes. Mechanical Appliances. Maintenance Pros and Cons. Chapter XV., Asphalte Pavements. Specifications for Materials. Methods of Construction. Mechanical Appliances. Maintenance. Causes of Failure. Chapter XVI., Wood Block Pavements. Decay and Preservation of Woods. Manufacture of Blocks. Construction and Maintenance. Chapter XVII., Stone Block Pavements. Manufacture and common sizes of Blocks. Construction. Chapter XVIII., Brick Pavements. Composition of Suitable Clays. Manufacture of Bricks. Abrasion Tests. Methods of Laying Bricks. Expansion Joints. Chapter XIX., Concrete Pavements. Methods of Mixing. One and Two Course Methods. Grouting. Method. Chapter XX., Miscellaneous Roads and Pavements. Burnt Clay, Straw, Shells, Slag, Clinker and Cobblestone Pavements. Chapter XXI., Street Cleaning

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and Snow Removal. Organization in Various Countries. Sweeping and Cleaning Machines. Chapter XXII., Tramway Tracks. Chapter XXIII., Conduits for Water, Gas and Electric Cables. Chapter XXIV., Comparison of Types of Roads and Pavements. Chapter XXV., Sidewalks, Curbs and Gutters. Chapter XXVI., Bridges, Culverts and Guard-rails. Chapter XXVII., Economics, Administration and Legislation.

ELEMENTS OF HIGHWAY ENGINEERING.—By Arthur H. Blanchard (497 pages). Published by Chapman and Hall, London. 1915. Price 19/-.

An abridged version of the Text Book by Blanchard and Drowne.

Chapter I., Historical Review. Chapter II., Economics, Administration, Legislation and Organization. Chapter III., Preliminary Investigations—Location, Drainage, Width, etc. Chapter IV., Surveying, Mapping and Design. Chapter V., Grading, Drainage, Foundations. Chapter VI., Earth and Sand Clay Roads. Chapter VII., Gravel Roads. Chapter VIII., Broken Stone Roads. Chapter IX., Bituminous Materials. Chapter X., Dust Prevention and Bituminous Surfaces. Chapter XI., Bituminous Macadam Pavements. Chapter XII., Bituminous Concrete Pavements. Chapter XIII., Sheet and Rock Asphalte Pavements. Chapter XIV., Cement Concrete Pavements. Chapter XV., Wood Block Pavements. Chapter XVI., Brick Pavements. Chapter XVII., Stone Block Pavements. Chapter XVIII., Street Cleaning and Snow Removal. Chapter XIX., Comparison of Roads and Pavements. Chapter XX., Sidewalks, Curbs and Gutters. Chapter XXI., Highway Structures.

Appendix I.—Glossary of Terms.
Appendix II.—Tests for Bituminous Materials.
Appendix III.—Tests for Non-Bituminous Materials.

15. ESTIMATING.

HOW TO ESTIMATE. BEING THE ANALYSIS OF BUILDERS' PRICES.—By J. T. Rea. Published by B. T. Batsford, 94, High Holborn. Price 12/6.

Chapter I., Introductory. Chapter II., The Cost of Buildings. Chapter III., Labour. Chapter IV., Preliminary and Provisions. Chapter V., Excavator. Chapter VI., Bricklayer. Chapter VII., Mason. Chapter VIII., Pavior. Chapter IX., Slater. Chapter X., Tiler. Chapter XI., Carpenter, Joiner and Ironmonger. Chapter XII., Smith and Iron Founder. Chapter XIII., Plumber and Zinc Worker. Chapter XIV., Plasterer. Chapter XV., Painter. Chapter XVI., Glazier. Chapter XVII., Paperhanger. Chapter XVIII., Gasfitter. Appendix Memoranda.

16. WORKS ORGANIZATION.

THE PRINCIPLES OF SCIENTIFIC MANAGEMENT.—By F. W. Taylor. Published by Louis Cassier. 7/6.

Gives an outline of new methods in organizing, training and handling labour, and gives many examples of the gain in efficiency that has resulted.

For example: *Shovelling ore at the Bethlehem Steel Works.*

Old plan ... 16 tons per man per diem
New plan ... 59 ,, ,, ,, ,, ,,

Bricklaying.

Old plan ... 120 bricks laid per man per hour
New plan ... 350 ,, ,, ,, ,, ,, ,,

Sorting Steel balls for bicycle bearings.

35 girls now do the work formerly done by 120 and with much greater accuracy. Hours of labour reduced by 2 hours a day, and in addition rest periods given during the day.

BRICKLAYING SYSTEM.—By C. Gilbreth. Published by Spon and Co. 16/-.

Motion study, showing how the motions of a bricklayer can be reduced from eighteen to five, with an improvement in efficiency from 120 bricks an hour to 350 the same time.

The method used may be used as a basis for the motion study of many other trades.

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PROFESSIONAL NOTE.

HYDRAULIC MINING CARTRIDGE.

THE object of the Hydraulic Mining Cartridge is to break up stone, coal, and concrete, or other hard substances, without using explosives. Its principal application is where the shock attendant on blasting operations would be damaging and dangerous to surrounding strata, foundations, etc.

The apparatus consists of—

(*a*) A rock-drilling plant,
(*b*) A hydraulic mining cartridge.

(*a*) *Rock-drilling plant.*—The plant normally used is a 4E Temple drill made by the Ingersoll-Rand Co., Ltd., driven either by steam or compressed air. A special 5″ diameter drill is necessary. This will drill a hole 2′ deep in hard concrete in about half an hour.

(*b*) *Hydraulic mining cartridge.*—The cartridge is made in several sizes, the most common size consisting of a cylinder 19″ long and 4″ diameter in which are fixed five hydraulic rams working at right angles to the cylinder, each ram having an area of about 3 square inches. This cylinder is connected by a hydraulic pipe to a hand pump which draws water from a small tank hung on the pipe. The apparatus complete weighs about 90 lbs. and can easily be handled by one man.

The cartridge attached to the pipe and pump is placed in a hole drilled by the rock-drill, the "liners" inserted to tighten the machine and the tank filled with water. By moving the pump plunger backwards and forwards, the water is transferred from the tank to the cartridge and pressure is then applied by means of screw and handles which carries the plunger forward and forces the rams out of their chambers in the cylinder and causes the concrete or rock to crack. This crack is extended for many feet on each side of the hole as the rams advance under the continued operation of the screw and handles. The total pressure obtained by the pump is about five tons per square inch or about 75 tons on the rock or concrete.

When seen at work at Shoreditch Electrical Power Station the apparatus was being used to remove heavy concrete foundation on which a marine engine had been bedded. Heavy holding down bolts

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increased the difficulty of the work. The splitting operation took less than 5 minutes, about 8 cubic feet of concrete being moved. The foreman reported that the cost of this method was about one-third of what it would have been if done by hand.

If necessary a loose face is made at the commencement of the job by the rock drill, after which, by careful placing of the cartridge holes, no further cutting should be required.

The manufacturers are "The Hydraulic Mining Cartridge Co." 115, Victoria Street, S.W.1.

REVIEWS.

THE HISTORY OF THE TWENTY-SECOND CHESHIRE REGIMENT, 1689-1849

By MAJOR-GENERAL W. H. ANDERSON, C.B. (Hugh Rees, Limited, 5, Regent Street, W.1.)

The history of the 22nd Regiment dates from the raising of the Regiment at Chester by the Duke of Norfolk in 1689 in aid of William of Orange, who had been invited in the February of that year by the Lords and Commons of England to take the place of the Stuart King James II. A short account is given of the war in Ireland and the Battle of the Boyne. The Regiment was subsequently employed at the Siege of Gibraltar in 1727 and at the Battle of Dettingen in 1743. It was at this battle that a detachment of the Regiment rallied round the King—George II—beat off an attack of French cavalry, and earned from the King the distinction of wearing an oakleaf in commemoration of their gallant conduct. They subsequently served in North America under Wolfe, and were one of the regiments that were present at the Battle of the Heights of Abraham before Quebec. They lost their Colonel, Abercrombie, at the Battle of Bunkers Hill in 1775, were present throughout the whole war of the American Revolution, evacuating New York on the 25th November, 1783, two months after the signature of the peace. In 1785 the Regiment was stationed at Windsor, where a Regimental Order of Military Merit was instituted by Lieut.-Colonel Crosbie and the Officers of the Regiment. The Order was intended to promote good conduct and discipline in the Regiment, the Field Officers, Captains, and Adjutant being members of the Order. No N.C.O. or private could become a candidate for election to the Order before he had "served His Majesty seven years with an unblemished character." The Order consisted of three degrees, which were distin-

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guished as follows :—1st degree—a silver medal, gilt ; 2nd degree—a silver medal ; 3rd degree—a bronze medal. Fourteen years' qualifying service were required before a candidate was eligible for the silver medal, and "a service of 21 years with an unblemished character" was necessary in order to entitle a member to a gilt medal. This Regimental Order of Merit was not finally abrogated until 1840 when the present medal for Good Conduct and Long Service was instituted throughout the Army. From 1793 to 1815—during the whole period of the Revolutionary and Napoleonic Wars—the Regiment served in the West Indies, India, and Mauritius. After leaving Mauritius in 1819 the Regiment served at home until 1841, when they embarked for India. Here they were destined to take part on the 17th February, 1843, in the famous Battle of Meeanee under the leadership of Sir Charles Napier.

As the only European Regiment to count Meeanee as a Battle honour, the Cheshire Regiment has always specially cherished the recollection of this fight, Meeanee Day being an annual celebration. Sir Charles Napier was Colonel of the Regiment from 1843 to 1853, the present narrative closing in 1849 while the Regiment was stationed at Bombay. It is to be hoped that a future historian may be found to bring the Regimental records up to date. The present narrative is vivid and interesting, and should do much to maintain the regimental *esprit de corps* of one of the most distinguished of our old Infantry Regiments.

B. R. WARD.

THE THEORY OF DIRECT CURRENT DYNAMOS AND MOTORS.

By JOHN CASE, M.A. (W. Heffer and Sons, Ltd., Cambridge, 1921. 15/-)

This book is primarily intended for students for University Honours Degree and other such examinations, and is not intended for the designer. It seems more especially suited as an addition to the more elementary books on electrical machines, which usually deal with the theory rather briefly. The work is divided into four main headings :—

(1) The theory of induced e.m.f.'s and currents.
(2) D.C. Generators.
(3) D.C. Motors.
(4) Efficiency and losses in D.C. Machines.

the remainder treating briefly with application of D.C. Machines to Traction, Multiple Wire Systems, and Boosters. The symbols used conform on the whole with those laid down by the International Electro-Technical Commission. Commutation and armature reaction are treated very briefly considering their importance with regard to the whole subject. The references to diagrams are somewhat erratic, lettering mentioned in the text often not appearing on the diagrams ; in one case (pp. 36, 37) lettering referred to in the text as on Fig. 27 does not appear, and on Fig. 28, which is just below the text in question, the lettering is exactly reversed. Though calculations are for the most

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part simple, a knowledge of higher mathematics is essential for a full appreciation of the work. In conclusion, in addition to its use for University students, the work should be useful as a reference book for those who may have to instruct others in the subject, where some knowledge of the theoretical considerations is essential, though not the complete knowledge necessary to a designer.

R.W.C.

NOTICES OF MAGAZINES.

MILITÄR WOCHENBLATT.

No. 31.—*The Draft of the Reichswehr Law.*—Some points in this are discussed. The Army and Navy Councils, which consist of representatives of all ranks, are for advisory purposes only; they have no power to decide any questions. The *M.W.B.* quite approves of this restriction, since it agrees with the principle that the best representatives of the soldier, when it comes to giving decisions, are his superior officers.

The formation of units on a territorial basis is expected to meet with many difficulties, particularly in the smaller states, but the Army Command did not feel able to oppose it.

Regulations providing for the discharge of *personnel* unfit for service are complicated. On one side the Reichswehr wishes to get rid quickly of all men not suitable for it, and on the other the Peace Treaty imposes strict limitations, so as to prevent all possibility of a reserve being built up. The *M.W.B.* says the *Entente* need not be anxious on this point because Germany is, for financial and other reasons not specified, quite unable to form any reserve. A special court is proposed, which shall consist of soldiers and shall be empowered to decide whether a man's conduct, on or off duty, renders him an unworthy member of the Reichswehr or not.

As regards politics, the Reichswehr man has the right to vote, but not to belong to any political association, or to conduct any political propaganda. He may belong to non-political associations, provided his district commander approves and may complain to the Ministry of Defence if approval is refused.

The Polish Threat against Upper Silesia.—Great anxiety is expressed regarding the alleged concentration of Polish divisions against Upper Silesia. The scarcity of all commodities and the low rate of exchange have given good opportunities in Poland for Bolshevik propaganda, even among those sections of the population which have hitherto been little inclined to listen to it, and the Polish Government is accused of trying to divert its people's attention to the desirability of acquiring Upper Silesia, with its great natural wealth, as a way out of all their troubles.

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The *M.W.B.* thinks that if the result of the Plebiscite turns out unfavourable to Poland, disturbances will be arranged, so as to give an excuse for intervention, which will end in occupation. The Polish troops are not thought to be of more than moderate quality, but as Germany is, save for a few frontier police, quite defenceless, they will easily be able to carry out their plans.

No. 32.—*A Criticism of the World-War.*—The author of this book, a German general staff officer, accuses the leaders of the German army of culpable ignorance of the real feelings and condition of their troops. He says that they continually looked at things through rose-coloured spectacles, and refused to face the true facts. General von Kuhl, who was chief-of-staff to Rupprecht's army group, declares that the accusation is unjustified. He states that every possible step was taken by the higher commanders to make and keep themselves informed regarding the condition of their men. G.H.Q. and army group H.Q. were always accessible to complaints and continually invited them by getting junior commanders to come and see them. He personally was frequently sought out by divisional and other commanders, who came with bitter complaints of the way in which their men were being worn out, and says he will never forget the impression made on him by the sight of units withdrawn from the Flanders front in 1917. Pale and hollow-eyed, coated from head to foot with mud, they dragged themselves apathetically back to their billets. Everyone knew how overdriven the men were, but their numerical inferiority and not the ignorance or self-seeking of their leaders, was the cause of it. He says that these accusations are only a part of the search for a scapegoat on whom the blame for defeat can be laid. He denies that Ludendorff only tried his great effort of 1918 because he was ignorant of the state of his troops, that the spirit with which they were then filled was forced into them, and that the only thing which made the troops willing to attack at all was the hope of making an end of all the "Schweinerei." He says that no one who saw the men before the March 1918 attack can doubt for a moment that their moral was splendid, and that to attempt to belittle it is only to rob the army of its glory.

Miscellaneous.—The Danish Government is said to be finding difficulty in filling the army establishments. In some cases only 20 per cent. of the N.C.O.'s and 50 per cent. of the officers authorized can be found, and the schools are almost empty. Better conditions of life in the commissioned and non-commissioned ranks are said to be the only remedy.

No. 33.—*Anti-Aircraft Artillery.*—The word "Flak" has been coined, from the initials of "Flieger-Abwehr-Kanone," to describe this branch of artillery, and Capt. Seydel contributes a short article on German Flak artillery. In August, 1914, there were only 18 Flak guns in the whole army and the development of the arm, as increasing demands were made upon it, met with great difficulties, which were never satisfactorily overcome. As the number and range of aircraft increased, demands for more Flak guns became so urgent that the first available weapons were pressed into use. The result was that at the end of the war there were no less than 25 different kinds of Flak guns in use. The bad effect of this lack of uniformity on training is obvious, and the

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construction of range tables, sights, etc., was much complicated thereby. Flak *personnel* was frequently, but usually unjustly, blamed. As a matter of fact the demands made upon it were very great and too often these were under estimated, with the result that unsuitable men were sent to Flak units. As an instance of their activities Capt. Seydel mentions that an average of 500 telephone calls passed through his group H.Q. daily. He claims that Flak were able to make enemy aircraft fly at an average height of 4,000 metres instead of 800, and that they brought down, from May to September, 1918, a total of 420 aeroplanes, of which 125 were shot down in September. He also mentions their value as anti-tank guns.

The Disarmament of German-Austria.—The treaty of St. Germain left Austria with an army of 30,000 men and a police and gendarmerie as in 1913. As a result of the lack of public security in Vienna and in the provinces these latter have had to be increased from a total of 8,600 to 19,000. This was all the more necessary because practically no "Einwohnerwehr" system exists. The *M.W.B.* would have expected Austria, when faced with this situation, to have applied to the *Entente* for further powers, but the socialists have preferred to make party rather than national capital, and have utilized the occasion to weaken the army. The result is that the Supreme Council has agreed to an increase in the police provided that the Army is reduced to exactly the same extent, that is to say, by 11,000 men. This will leave Austria with an army of 19,000 all ranks.

A Letter from Palestine.—Frau Emma Wagner writes from Nazareth at the end of 1920:—

"DEAR——It is over two years since that terrible 20th September dawned on Nazareth. It was like a nightmare. At six o'clock in the morning there was a knock at the door and the words, 'I am an Englishman.' Everywhere the cry, 'The English' burst like a bomb among the unsuspecting sleepers. Machine-gun fire was soon heard from the Franciscan monastery and elsewhere, and, in spite of the surprise, the defence soon pulled itself together. By ten o'clock the English had withdrawn, and the Germans and Turks were able to get away. The English general who ordered the withdrawal was afterwards degraded, chiefly because he let Gen. von Sanders escape. The English were furious when they heard that he was the last to leave the town, at five o'clock in the afternoon. At last the 'conquerors' came, but with what caution! The Bedouins who had been prowling, like jackals, round the town, now gave place to the hyænas! Occupation of the town took several hours, and was then accomplished chiefly by Indians; There were very few English officers. All honourable Englishmen speak with the greatest respect of the performances of the Germans and particularly of the defence of Samakwe. The capture of Palestine cost the English quite enormous loss in human life, although they usually sent the Australians and Indians to the front, when there was any fighting to be done. Some of them boasted openly that they had bought Palestine, and one highly-placed officer even named the price. Our treatment has altered in a remarkable way, and we are met everywhere with the greatest politeness and kindness. Since it was decided in

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England that German colonists in Palestine were not to be disturbed, not only the Red Cross and the English Quakers, but also the Mahomedans and Jews have behaved well to us. Nazareth, after her crowded hours of 1918 has fallen asleep again and the sleep is deeper than ever."

No. 34.—*The military and political situation in South-Eastern Europe.*—While all the so-called national states, which compose South-Eastern Europe, still view each other with deep suspicion and mistrust, a feeling is beginning to spread that this cannot go on indefinitely, and that if any recovery or progress is to be made, some sort of agreement must be reached.

Progress in this direction has been made by the states of the "Little *Entente*;" and, as Austria is no longer to be feared, economic agreements have been made between her and the Tchechs, Roumanians and Serbians. Hungary, on the other hand, has so far consolidated her military strength as to be an object of suspicion, as has also Bulgaria. Germany has concluded agreements with Austria, Tchecho-Slovakia, and Hungary, but the effects of them remain to be seen.

The Danube question is very important, but the international commission is now sitting and steps are being taken to establish canal communication between Rhine, Elbe, and Danube.

Occasionally there is talk of a Danubian alliance, under Hapsburg direction, but at the time of writing there seems to be little prospect of it coming to anything. Austria and Hungary are against it and Bavaria is not likely to cut loose from Germany.

In Tchecho-Slovakia the Army of 200,000 men, is nearly complete, but its gradual reduction to 150,000 is in view; 28 per cent. of it are Germans. Returned legionaries from Russia and Siberia form a troublesome element, as they are inclined to be revolutionary. Internal political conditions are very much as in Germany, and the economic position is not bad.

Austria's position is very difficult, and union with Germany is everywhere canvassed. Food and clothing are short and financial conditions go from bad to worse.

Roumanian demobilization is not quite complete. Soviet-Russia has not yet agreed that Bessarabia shall be Roumanian.

Jugo-Slavia is still far from settled. The Albanians are giving local trouble and the Croats are demanding a republic. The constitution of the Army has been decided; it is to have 16 divisions in first line, with similar divisions in second and third line; equipment for the third line is lacking. As in all the new states the great political question is whether a single state or a confederation shall be formed. Great efforts are being made to join the Danube by a railway to the Adriatic at Cattaro.

Bulgaria is making good progress. The Army has been reduced to the 20,000 men allowed and the Gendarmerie raised to 13,000. Conscription of labour is in force. Several Generals are to be brought to trial for their failure in the war, but the *Entente* has withdrawn its demands for the trial of war criminals. The amount of land which may be owned by an individual is limited to 30 hectares and property is

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heavily taxed. Economic conditions are, however, improving and prices are falling.

Greece is in difficulties; 200,000 men are still under arms and the army is divided into Royalists and Venizelists. The nation is longing for peace and demobilization. Withdrawal of economic support by the *Entente* has caused many difficulties.

Hungary has made more progress than any other country in S.E. Europe. The state is consolidated and the army firmly built up to the size allowed.

Cost of troops in armies of occupation on the Rhine, shown in paper francs per day.

	Officers.	*Men.*	*Horses.*
French	47	13	7
Belgian	46	13	11
American	160	59	11
British	98	32	13

L. CHENEVIX-TRENCH, *Major, R.E.*

REVUE MILITAIRE GÉNÉRALE.

September, 1920.

The First Strategic Check of the German Armies. (by Capt. Koeltz).—The battle of the Sambre and the Meuse, which took place between the 20th and 25th August, 1914, was a tactical success for the Germans, but a strategic failure. The two rivers, and the Central Canal, were all crossed, but the left wing of the Allies was not outflanked as had been intended by von Schlieffen's plan of campaign. The failure is attributed firstly to von Moltke, secondly to von Bulow, and thirdly to von Haussen. Von Moltke for some reason, either excess of optimism in relying on the weight of the German force engaged as compared with the estimated strength of the opposing allies, or excess of confidence in his subordinates, or the multiplicity of matters claiming his attention, renounced the direction of the three armies on the right flank in this the most important battle of the opening of the war. He had already placed the First Army (von Kluck) under the orders of von Bulow, commanding Second Army, and during the afternoon of 20th August directed von Bulow and von Haussen (Third Army) to co-operate strictly in the proposed attack on the allied forces on the line of the two rivers west and south of Namur. Again, von Bulow, a man of little imagination, evidently entirely failed to grasp the strategic aspect of the situation, or perhaps feared the damage to his reputation which a defeat would involve, and restricted von Kluck to close attendance on the movements of the Second Army, as well as a watchful attitude in the direction of Antwerp. Von Kluck, who had known for some time that he was to command the extreme right of the outflanking movement, and had devoted much time and study to the subject, expostulated and asked for at least a corps of cavalry, without which he was unable to

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feel for the left flank of the Allies, but von Bulow retained both the cavalry corps which he disposed of under his own orders, either in his own immediate front, or too far to the north-east, and only placed one corps under von Kluck's orders from the morning of the 24th. Von Bulow also hampered the movements of von Haussen. Late on the 23rd he implored the latter to come to his assistance by marching across the Meuse in a westerly direction, while von Haussen had already issued orders for an early advance next day in a south-westerly direction across the river, with the object of getting behind the French, who he knew were retiring from the line of the Sambre. Such a movement had even been directed by the Great General Staff, who on that date intervened in the conduct of the operations. Von Haussen, understanding from von Bulow's appeal that the latter was in difficulties, and not expecting such a senior general to ask for help unless he really needed it, against his better judgment cancelled the orders he had issued, although they were then in course of execution. The consequence was that the French withdrew without difficulty, while, owing to the limitations imposed on von Kluck, the English were able, by retiring, to escape being outflanked. It is possible that if the Armies of the German right wing had been grouped under a separate commander who was not also occupied by the responsibility of commanding one of the armies he would, even if a von Bulow, have had a clearer insight into the strategic possibilities open to him, and which the superior strength of his forces would have enabled him to turn to account. There is little doubt that the allied left should have been overwhelmed had the German armies been more intelligently handled.

October, 1920.

The Arrest of the German Offensive on the Ourcq in 1918. Operations of the 2nd Cavalry Corps from 28th May to 5th June, by Col. R. Bouillain.—The operations are given in detail. The Corps covered 200 to 215 kilometres in three days' forced marching, and then held a front of 12 kilometres almost denuded of other troops, in contact with two, then three, German divisions, one consisting of the Guards. This entailed five days of incessant fighting and rapid changes of position. The Corps lost one-third of its effectives, but checked the enemy offensive by its sudden and unexpected resistance, until other troops could be brought up to fill the gap and bar the road to Paris.

Some Reflections on the Military Services Act. (by Col. P. Defrasse, Reserve Artillery).—The writer advocates giving the Government sufficiently wide powers to enable it to raise, in case of need, a force larger than that normally required. The Act of 1872 (called the Five Years Act) allowed a large number of total exemptions, besides which the Minister for War was empowered to allow a proportion of those liable for service to serve for one year only, the proportion being fixed at his discretion, and the individuals chosen by lot. Service for the remainder was nominally for five years counting from 1st July, but the contingent was seldom called up until November, and was generally dismissed after the manœuvres in September of the fourth year of service, so that practically service was for 3 years 11 months

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only. The elasticity of this Act is its great merit. The strength of the Army could be increased at will as the need arose (1) by calling up each contingent at due dates, *viz.*, 1st July; (2) by reducing, or cancelling entirely, the proportion allowed to serve for one year only; and (3) by keeping the whole force with the Colours for the full five years permissible. These peculiarities were no doubt recognized by the Germans, and may have had their effect on the maintenance of peace. The Three Years Act of 1889 cancelled all exemptions except actual incapacity for service, but still allowed of one year's service only for a proportion; its elasticity was much less than that of the 1872 Act. The Two Years Act of 1905 allowed of no elasticity, and on a crisis emerging had to be superseded by a new Act, which was passed barely in time to produce its effect by the dates a larger army was actually necessary. A Three Years' Act authorizing the call of the contingent later than the legal date, and allowing of leave being granted before the legal date of termination of service, would meet the case provided it creates at the same time a sufficiently strong professional nucleus to provide the frontier guards, and to train the citizen soldiers.

November, 1920.

Notes on the War in the Air near Nancy. An answer by Capt. P. Weiss to the query, "What are our aviators doing?"—The inhabitants of Nancy, after the opening of the war, never experienced a great battle, but bombardment by long-range guns and the war in the air did not cease. Early in 1917 the German long-range gun cleverly hidden at Hamport was put out of action in six hours after 18 shots directed by aeroplanes, in spite of all efforts of the Germans, and was never re-installed. Many other guns did not cause so much trouble, but one which fired on Pompey was almost impossible to locate. It had two emplacements, connected by the Metz-Delme railway, sited in a wood and fired every Sunday morning, when the wood was smothered in a smoke cloud and flashes were fired to distract the French observers. It was quite impossible to tell, except by sound, which emplacement was in use, or where the French shots fell. Although the emplacements were destroyed each Sunday afternoon the gun was regularly at work again next Sunday. The writer argues from his experience that it is impossible to prevent night attacks on a town by hostile air-craft. Guns and balloons ensure their keeping at a great height, but chases by night are seldom effectual, and though the English have several destroyed machines to their credit, such battles are exceptional. To prevent guns firing on their own air-craft at night it has been suggested that the sky should be divided into zones, in one of which aeroplanes should be given full liberty of action, while the other is left free for the artillery. The Paris defensive aeroplanes obtained no success by night chasing, and there were many accidents to returning machines on landing. The reason is, that the best pilots cannot resign the excitement of air warfare on the battle front to take up the more passive duty of guarding from attack a town on an otherwise quiet front. Second rate pilots have not the nerve and dexterity obtainable only by constant practice. The only object in allotting defensive squadrons to towns is the moral

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effect on the inhabitants of knowing that their requirements in that particular have not been neglected. The squadron at Nancy, moreover, was not expected to fly by night, but only to patrol by day, and its success in this duty is proved by the almost complete cessation of German aeroplane attacks by day from early in 1917. Every week two or three captured planes were on view, and constant attacks were made on railway stations, munition dumps, workshops, etc., in the German lines, as well as photographing and reconnoitring flights. The records of the Eighth Army Squadron in 1918 are quite brilliant, it was used on every sort of air service by day. Four pilots out of twelve gained the title of "Ace," and the way the mechanics worked, often all night, is beyond praise.

Events in Upper Silesia.—An account of the occurrences in Upper Silesia from June to August, 1920, resulting in a rising of the Polish miners against the Germans. On this occurring a state of siege was proclaimed at Kattowitz, and General Gratier and M. Kuhn, President of the Allied Commission, announced that they had full power to restore order, advising the German population to remain calm. The rising spread to other places in the mining districts, and a deputation of Polish workmen, who appear to have behaved very moderately, represented their grievances to the Commission. On 25th the Allied flags, which had been torn down on 17th, were rehoisted, and on 26th the repatriation of the Sicherheitspolizei to Germany began, and work was resumed in all the mines. On 28th the terms agreed upon were published; return to Germany of the Sicherheitspolizei, and their replacement by a mixed force pending the constitution of the plebiscite police, expulsion of all persons (mostly German reservists) who had entered the country since 1st August, 1919, subject to exceptions to be adjudicated upon by a mixed tribunal, punishment for refusal to hand in firearms, and constitution of a mixed commission to prevent acts of terrorism by either side.

A. R. REYNOLDS.

PROBLEM.

PROBLEM 23. Solution (G. F. S. Hills, Esq.)

Write the division sum as follows :—

$$
\begin{array}{l}
abc\ )\times\times\times\times\times 4\ (u4vw \\
\quad\ g\ e\ f \\
\hline
\quad m_1 m_2\ 4\ m_4 \\
\quad n_1\ n_2\ n_3\ n_4 \\
\hline
\quad\ \ p_1\ p_2\ p_3\ p_4 \\
\quad\ \ \ q_1\ 4\ q_3 \\
\hline
\quad\ \ \ r_1\ r_2\ r_3\ 4 \\
\quad\ \ \ r_1\ r_2\ r_3\ 4 \\
\hline
\end{array}
$$

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(i). It is clear that $p_1 = 1$, by considering the sum of the two three figure numbers $q_1 4 q_3$ and $r_1 r_2 r_3$.

(ii). If the divisor $10^2 a + 10b + c$ is represented by N then clearly $4N > 10^3$ as it is equal to the four figure number $n_1 n_2 n_3 n_4$, further $v.N < 10^3$ as it is equal to the three figure number $q_1 4 q_3$, therefore $v = 1$, 2, or 3.

(iii). If $v = 3$ N lies between 250 and 334.
If $v = 2$ N ,, ,, 250 and 500.

(iv). As $q_3 = 4$ it is clear on consideration that
when $v = 3$ b must be either 8, 1 or 4,
when $v = 2$ b must be either 2 or 7,
when $v = 1$ b must be 4.

(v). The two numbers c and w are connected by the fact that their product must end in 4, so that for each value of w there is one or in certain cases two values of c, *e.g.*, if $w = 1$ then $c = 4$.

(vi). When $v = 2$ or 3 the limitation resulting from (iii) (iv) and (v) restricts the number of possible cases to be tested to a very small number. The test to be applied is that $4vw \times abc$, which must make the six figure number $m_1 m_2 4 m_4 b_4$, must make $m_3 = 4$. The test shows that no cases exist where $v = 2$ or $v = 3$.

(vii). When $v = 1$ and therefore $b = 4$ there are a larger number of possible cases. These cases result by giving different values 1 to 9 for the letter a, and different values 1 to 9 to the letter w. The letter c is determined from that given to w by (v). The field of choice can be restricted by noting that as $p_1 = 1$, $(10 + w) N > 10^4$, so that if $w = 9$ $N > 526$, if $w = 8$ $N > 550$, and so on. As a is 5 or more referring to gef we see that $u = 1$. Further a cannot be less than 7, for suppose $a = 6$ abc becomes $64c$, and this when multiplied by 4 gives $n_1 n_2 n_3 n_4$ and $n_1 n_2 = 25$, and therefore $m_1 m_2 = 26$ or 27. In this case the maximum value of $m_1 m_2 4 + gef = 274 + 64c$ and this is less than 1000, but the condition of the problem requires this sum to be not less than 1000. Hence $a = 9$, 8 or 7. Further in carrying out the test $4vw \times abc$ to see whether $m_3 = 4$ it will readily be found that for any particular value of a it is unnecessary to test for more than a few values of w.

In this way the field of possible cases is much limited and it will be found that 4 cases exist.

(viii). The four cases are

$$949 \times 1416 = 1343784$$
$$943 \times 1418 = 1337174$$
$$846 \times 1419 = 1200474$$
$$848 \times 1418 = 1202464.$$

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THE VALUE OF HELIGOLAND.

By COL. J. C. MATHESON.

A CONSIDERABLE amount of interest has been evinced from time to time in the military aspect of Heligoland, and, as a general rule, statements on the subject, especially in the public press, give a very high value to the place. But, when all the facts about this diminutive rock are duly weighed, it is contended that this high value is greatly exaggerated.

In the aspect under consideration the geographical position of Heligoland is naturally of primary importance and in studying this position it is advisable to use a small scale map. From this it will be observed that the island lies near the head of the bight formed by the north coast of the province of Hanover and the west coast of Schleswig-Holstein. It is 28 miles due north of the nearest Frisian island, Wangeroog, 30 miles west of the Schleswig coast, 40 miles from Cuxhaven at the mouth of the Elbe and 50 from Wilhelmshaven in the Jahde.

There is very little difference in the distances of important points on the British Coast from Heligoland and from other German bases in its neighbourhood. This is clear from the table of mileage (approximate) given below :—

Heligoland to Norfolk (nearest British coast) ...	280	miles.
Cuxhaven ,, ,, ...	295	,,
Emden ,, ,, ...	240	,,
Heligoland to Scapa Flow	530	,,
Cuxhaven ,, ,, ...	560	,,
Emden ,, ,, ...	540	,,
Heligoland to Dover	340	,,
Cuxhaven ,, ,, ...	375	,,
Emden ,, ,, ...	310	,,

An inspection of all these distances shows that Heligoland is too close to Germany to be of value to her as an advanced base. On the other hand the island is too near the German coast and so too vulnerable to be a base for enemy attack on that coast. It is also too far from the coast to form an integral part of the coast fortresses at the mouths of the Elbe, Weser, and Jahde.

Apart from its position Heligoland has inherent drawbacks as a

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base. The chief of these is its small size. Everything is cramped, the armament cannot be pushed out in advance of the object of defence and it is impossible to obtain proper bases for range-finding. The rock is only 1,700 yards long by 600 yards broad at the south end, while it narrows to a point at the north. The harbour and breakwaters add a little to its size and the Düne Islet, a short mile to the east, is of some assistance, but the longest base available for range-finding was only 2,930 yards.

Its small size and exposed situation prevented the use of Heligoland as an air base for any air-craft except sea-planes. Airships and aeroplanes were never used from it. Another drawback to the place, considered as a base, was that all stores required for the replenishment of any craft had to be transported to the island, even fresh water.

With all these drawbacks however Heligoland undoubtedly had a value for Germany. It covered the access to the rivers of the bight and the exit from them. It gave shelter to mine-layers and mine-sweepers and so facilitated the upkeep of the German minefields although it was not indispensable to them. Its guns could nearly reach all the navigable water between it and the mainland although it could not ensure the safety of a fleet behind it from attack by submarines or small craft at night.

Taking all these points into account it is contended that Heligoland was an outpost and an outpost only and that while it was worth while to fortify it as such, any works on a larger scale were a mistake. That this was not the view of the Germans is plain from the facts of the case. Immediately after obtaining possession of the place in 1890 they commenced its fortification, at first on a fairly moderate scale but at a later date on a much larger one. These later works were completed only about a year before the outbreak of the Great War.

It might have been thought that the Germans would have recognized that the chances of this island being attacked deliberately were almost infinitesimal, but the facts do not bear this out. Not only was the armament a numerous and a heavy one, but the idea of *protection* seems to have been paramount. This is brought out by the following particulars of the works:—

(*a*). The large guns (12″) were in turrets with 16-inch armour.

(*b*). The magazines and all underground works had two metres of the best ferro-concrete over them. These works included power-stations, quarters for officers and men, hospitals, in fact all the elements of a barracks. There were two of these "warrens" on the island.

(*c*). A heavily protected tunnel ran from one end of the island to the other, connecting all the main works.

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(*d*). Fire-command posts had seven inches of armour over them, while all the position-finding stations except one (a war construction) had periscopic telescopes with armoured heads. These periscopes introduce chances of error which are avoided in direct sight telescopes and in this case, with the very short bases available, every chance to minimize error should have been sought.

The primary armament of the place consisted of :—

(i). Four turrets, each containing two 30·5-cm. (12″) guns.
(ii). Four 21-cm. guns, mounted singly in cupolas with 2-inch armour.
(iii). Eight 28-cm. howitzers, mounted singly in sunken pits.

The secondary armament comprized :—

(*a*). On the tableland, one 15-cm. gun and four 8·8-cm. guns at each end of the island.
(*b*). At the harbour, four batteries mounting altogether four 15-cm. guns and twelve 10·5-cm. guns.

An ample anti-aircraft armament was provided in addition to the above. This comprized 19 guns varying from 3·7-cm. to 10·5-cm., while there were anti-aircraft machine guns as well.

All the secondary batteries at the harbour were constructed either just before or just after the commencement of the war. Their design was in striking contrast to that of the larger batteries as the guns were crowded together and the protection was somewhat below the average pre-war practice in this country. In one place eight guns were huddled into 150 feet of frontage with practically no traverses between them.

The style of the defences is shown by the drawings annexed to these notes. They are :—

(*a*). A general plan of the island showing the majority of the works. Some minor ones have been omitted for the sake of clearness and the searchlights also are not shown. The harbour to the south of the island is purely artificial, it could be used only by craft up to the size of destroyers or very small cruisers. The Düne Island is very low-lying and its long "tail" has the faculty of most tails in that it can "wag," as gales from north or south cause it to shift to a surprising extent.
(*b*). Plan and sections of the South Group. These give a good idea of the massive nature of the works.
(*c*). North Command Post.
(*d*). East Mole Battery.

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The photographs show :—

(1). An air photo of the island taken from the south.
(2). Exterior of the South Command Post.
(3). Part of the tunnel which ran through the island.
(4). Turrets "Dora" and "Cæsar."

Regarding the fortress of Heligoland as a whole and taking into account also the other works on the German coast together with the earlier batteries constructed on the Belgian coast, it would seem that, prior to the War, the Germans had not assimilated the teaching of history as regards coast fortifications. This is especially interesting in view of the fact that they themselves fought one of the most remarkable actions ever contested between ship and shore, in 1849 at Eckernförde on the coast of Schleswig-Holstein against a Danish squadron. In this action the two principal ships surrendered to the batteries on shore. It may be said that much has happened in 70 years, but what has not happened is that the relative value of guns ashore and guns afloat has altered in favour of the latter, even in this great war.

Coast fortifications are good servants but they can very easily become bad masters. They are purely defensive works and while some are absolutely essential they must never be overdone. The opinion is put forward that in Heligoland they were overdone to a very high degree. Heligoland could have served its purpose fully at a fraction of the expenditure that was poured out on it. Who can say what would have happened if the saner view had prevailed and most of the money that was spent on Heligoland had been used for active measures of war instead of passive ?

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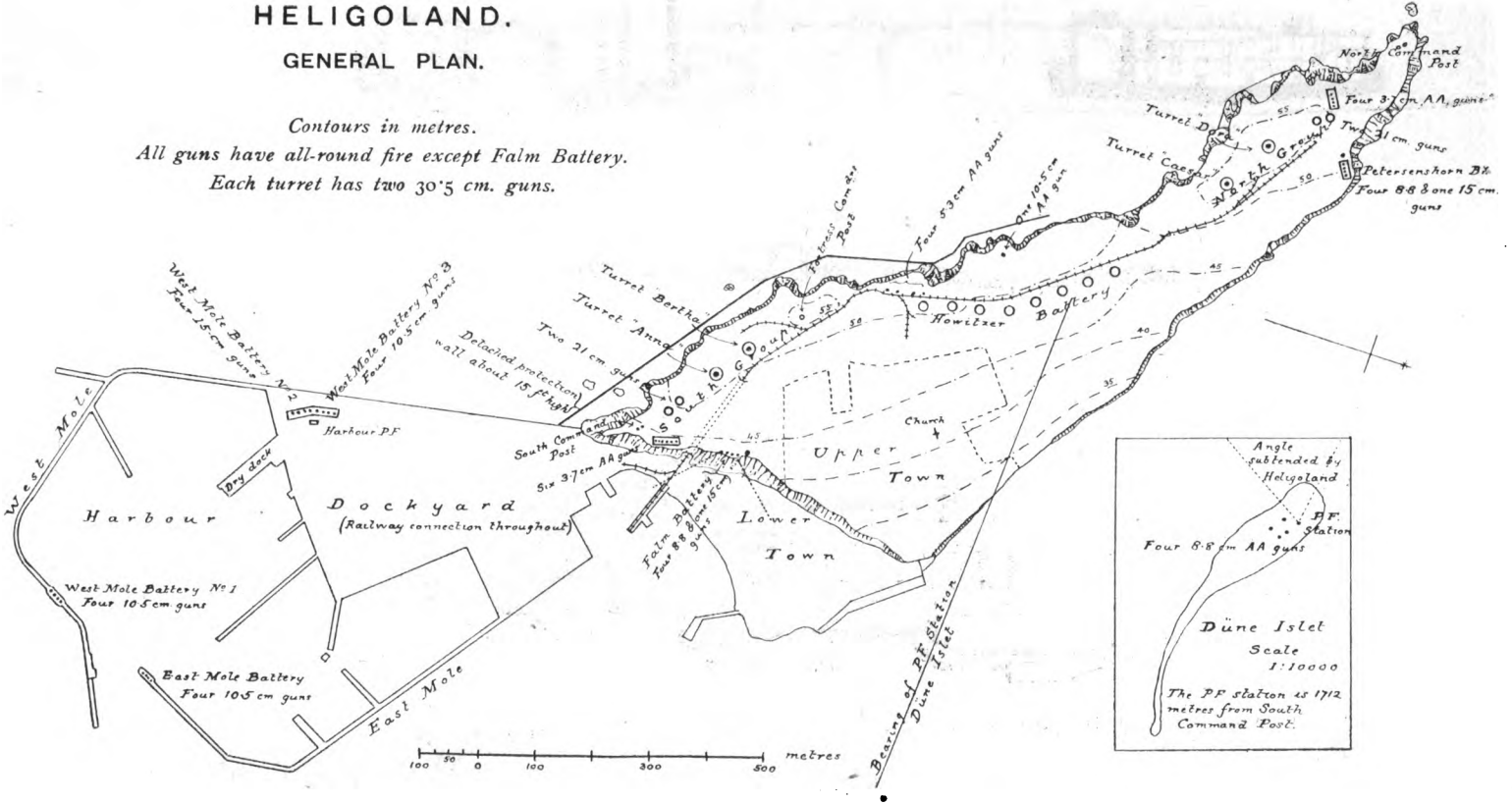
HELIGOLAND.

GENERAL PLAN.

Contours in metres.
All guns have all-round fire except Falm Battery.
Each turret has two 30·5 cm. guns.



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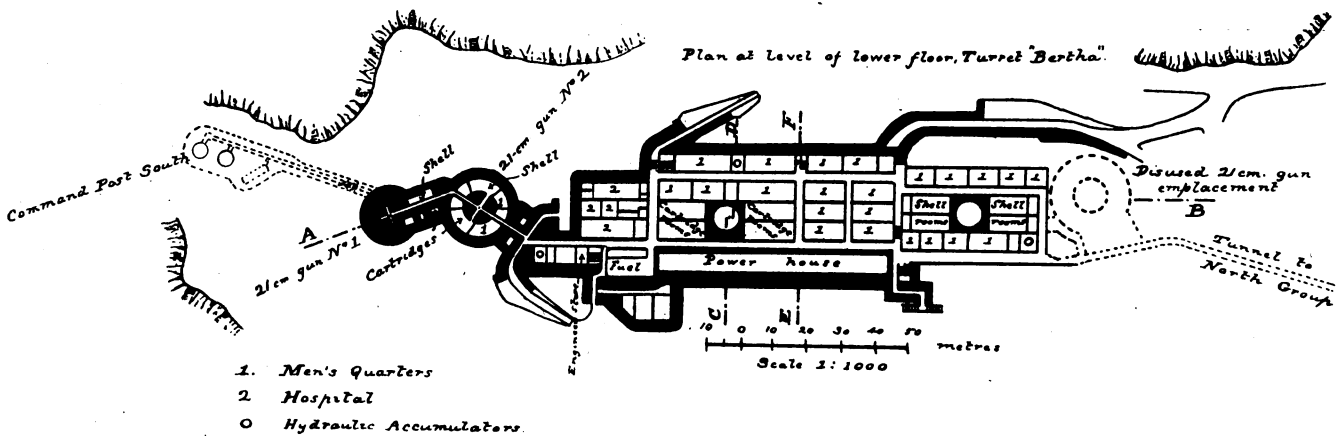
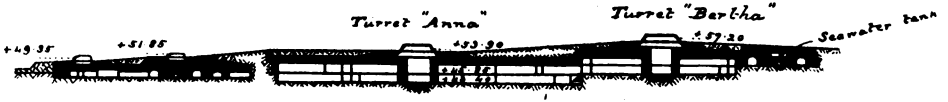
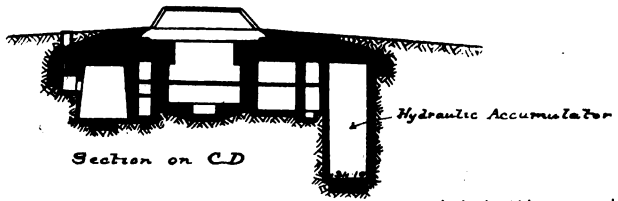
HELIGOLAND.

SOUTH GROUP.

Heights in metres.







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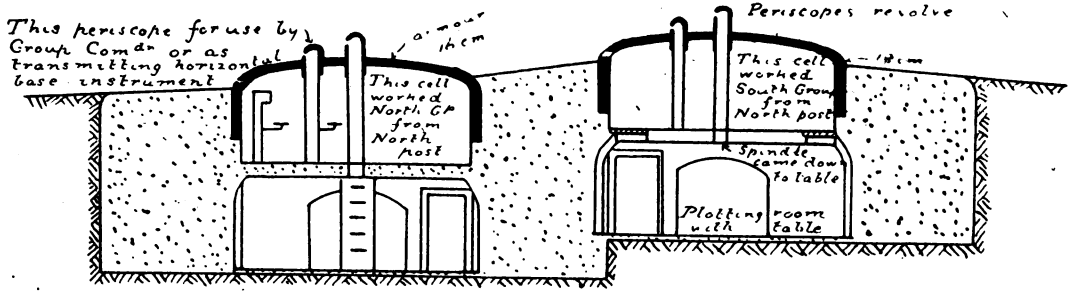
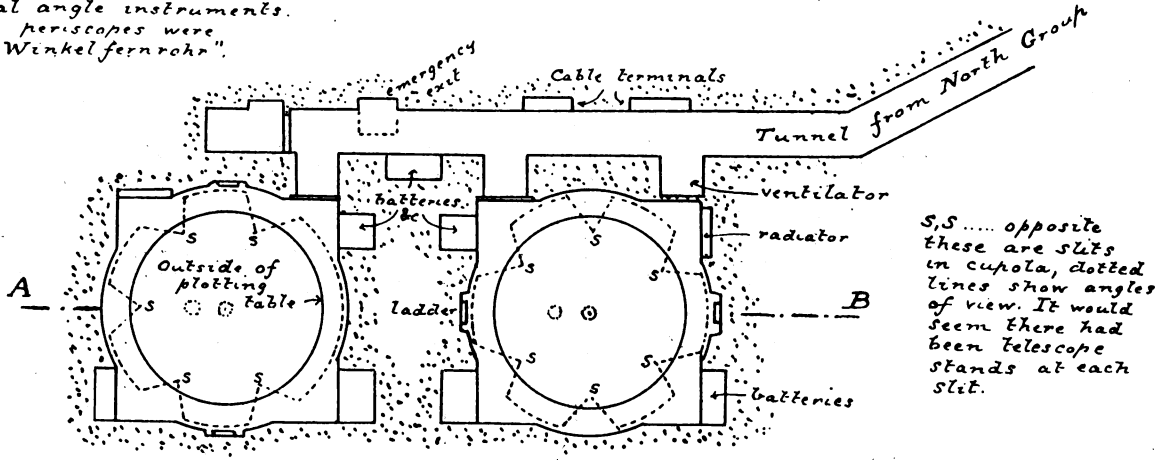
HELIGOLAND.

COMMAND POST, NORTH.


This periscope for use by Group Comdr or as transmitting horizontal base instrument
a mour them
This cell worked North Gp from North post
Periscopes revolve
This cell worked South Group from North post
Spindle came down to table
Plotting room with table

Section on AB

Central periscopes ("Peilrohr") were long base horizontal angle instruments. Eccentric periscopes were called "Winkel fernrohr".



Plan of Lower Floor

(c)

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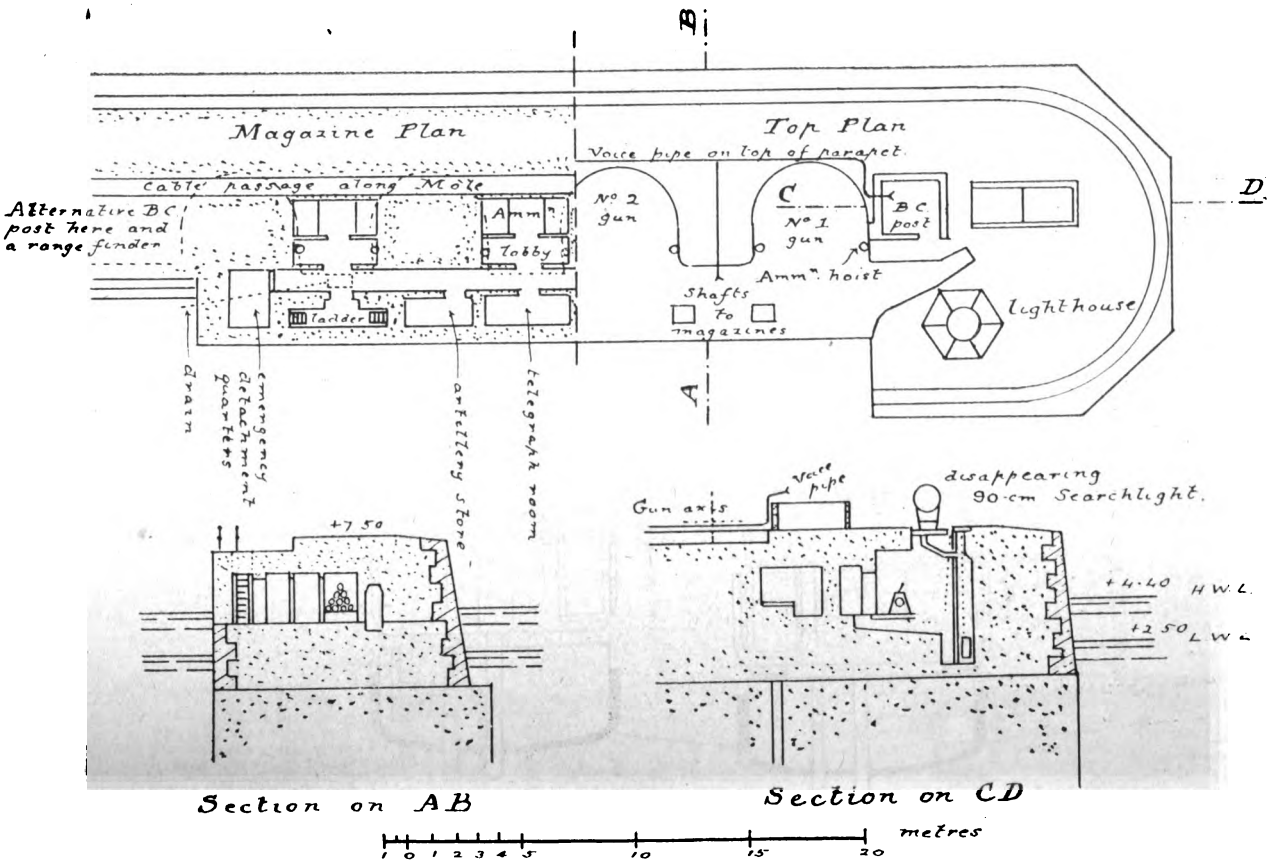
HELIGOLAND.

EAST MOLE BATTERY.



(v)

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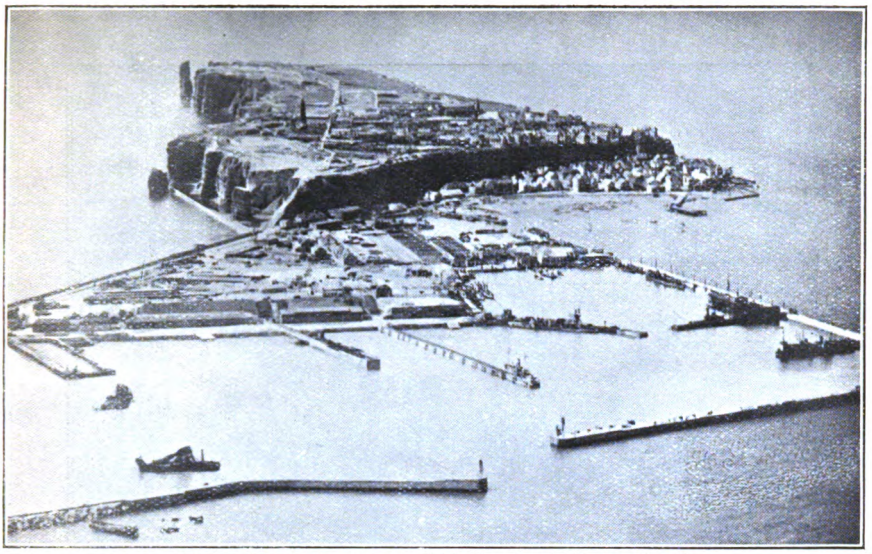
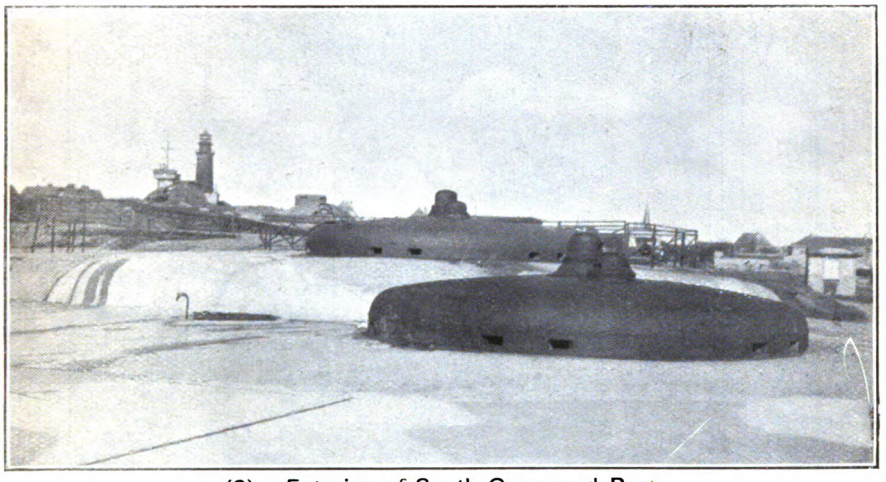
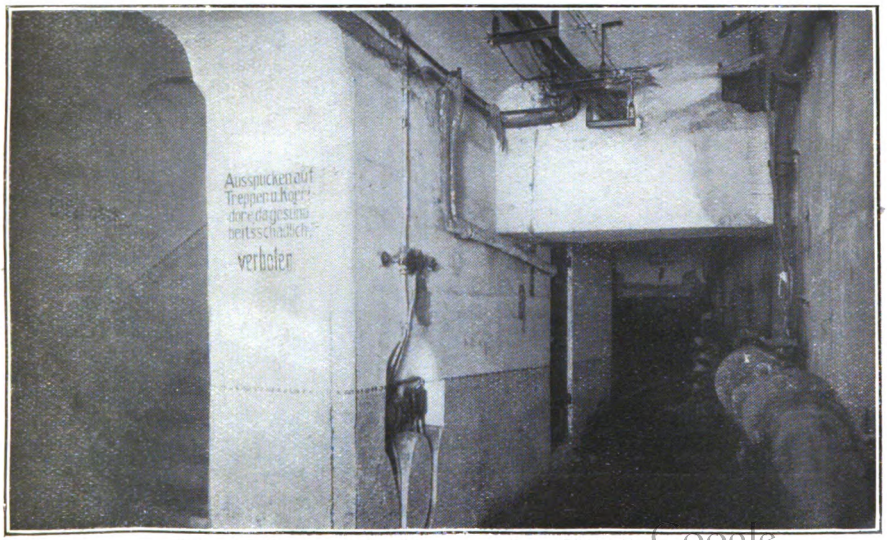


(1). Air photograph of Heligoland, from South.



(2). Exterior of South Command Post.



(3). In the tunnel which ran through the island.

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(4). Turrets "Dora" and "Cæsar."

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ENGINEER INTELLIGENCE.

A lecture delivered at the S.M.E., 17th Feb., 1920, *by* BRIG.-GENERAL J. E. EDMONDS, C.B., C.M.G.

DURING the War one of the thoughts that constantly occurred to me, and no doubt to many others, after finishing a bit of work, was " how much better I should do that job if I had to do it a second time." My purpose to-night is to place before you my experience in regard to Engineer Intelligence, so that, at any rate, you, if you ever have to deal with it, may, to some extent, be able to begin where I left off. Experience is one of the few advantages of middle age over youth. What I shall say relates solely to Belgium, France and Germany, but of course will apply to many countries. I may be a little critical at first, but I hope I shall also be constructive.

A short paper condensed from a report that I wrote on the subject at the end of the War has already been published in the *R.E. Journal* (February, 1920, " Organization of Engineer Intelligence and Information.") It gives a useful summary of the work done, and forms the frame-work of what I have to say to-night.

When some years ago I sat where you sit, as a young officer, I knew nothing about the Intelligence Division of the War Office, not even of its existence. I suppose that the world has advanced since then and that you are acquainted with its general organization. You will find an excellent article on Intelligence in the *Army Quarterly* for January.

It is unnecessary to define Engineer Intelligence to this audience. I will merely say that it means any information that will enable military engineers to prepare for and execute their work. It includes information about the theatre of war, of the enemy's engineer practice, also of our own practice and that of Allies, and of experimental work. To give you an example, it will include information of the water supply of the theatre of war ; but it is not sufficient to know that there is an elaborate peace system of reservoirs and pipe supply, for this may be destroyed ; there must be information of the geological formation of the country, so that we may know where to bore for water ; we should know the boring apparatus required, and the nature of pumps that are most suitable, in order that they can be provided in good time. We must have information of the nature

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of the rivers and canals, so that our bridging equipment may be suitable. That we must know all about the enemy's engineer methods and stores is obvious; two stores we certainly borrowed from the enemy: the wire entanglement screw picket and the spring percussion fuze for firing charges. The organization of defence in deep zones, outpost, battle and rear, we undoubtedly copied from him. We also learnt of spider wire, and that 1.5 metres of ferro-concrete is sufficient protection from even heavy shells.

Then there must be circulation of information of new methods, etc., in our own and Allied Armies. To give two instances we borrowed *Réseau Brun* (French wire) and the Elephant shelter from the French; the "A" revetting frame worked out in the Second Army, the cork float bridges devised in the XV. Corps, and Colonel Sankey's floating bridges for lorry transport, had to be made known to all, etc., etc.

We had very little engineer information about the theatre of war when hostilities commenced. This was not the fault of the General Staff, nor of the R.E. authorities, nor in particular of those officers who were both G.S. (I.) and R.E. To convince you of this, I need only enumerate a few names of those who had this double qualification in the years before the War:—Sir John Ardagh (once Commandant S.M.E. and later D.M.I.), Lord Nicholson (who followed him as D.M.I. and was subsequently the first C.I.G.S.), Sir George Macdonagh, Agar, Bruce-Williams, Manifold, Bannerman, S. H. Wilson and Bowdler.

Engineer Intelligence, nevertheless, is not difficult to obtain in peace time. But, as Sir Charles Caldwell has said in his *Experiences of a Dug-out*, with regard to lack of information of a certain theatre:—

"To have obtained full information as to the Gallipoli Peninsula and the region round the Dardanelles, but especially as to the peninsula, was a matter of money—and plenty of it."

The collection means visits to the country concerned and keeping in touch with persons, not in the Army, who for business or pleasure visit it. It may mean arranging for persons to reside in that country and getting in touch with persons who permanently live there. The matter never rests—if one has compiled a complete handbook, it must be kept up to date. Even if the material can be got for nothing, there must be a staff to collate it, to sift out what is of military value, to watch for changes and innovations, and arrange to get the information about them. All this means money.

Now, money for Intelligence purposes, through the short-sightedness in things military of one Government after another, was always lacking—there is not a pin to choose between the politicians who govern the country in this matter. Both Unionist and Liberal Ministers refused sufficient funds. Yet you find that the article in

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the *Army Quarterly* to which I have already referred ends with the words, " Efficient intelligence is the best form of national insurance though the premiums are high." As you may see in the report of the Enquiry on the Conduct of the War in South Africa, the Intelligence Division of those days was allowed £200 a year to collect information about the South African Republics. Just before the outbreak of war twelve Staff Officers were despatched to get information of the theatre of war. But it was too late, such information can only be collected in the leisures of peace. You may recall that we had no maps, far less engineer intelligence of our own territory, Natal and Cape Colony. This kind of history gets forgotten, we remember only our successes. I mention it so that when some of you come to sit in the seats of the Mighty, you may remember the warning of 1899. Affairs improved slightly after 1902. I think we had sometimes as much as £2,000 a year—little enough to conduct enquiries over nearly the whole globe (the Intelligence Branch, Simla, dealt with the countries adjacent to India). For a further trouble was that we didn't know where we might not have to fight next. It might be the Frisian Islands, or Sleswig (according to the views of the late Lord Fisher), Belgium, the Sinai Peninsula, Asia Minor, Afghanistan or China. I don't think the most enthusiastic of us contemplated Germany, the German colonies, Northern Russia, Salonica, Palestine and the Caucasus, far less Central Asia, as possible theatres of war. Germany's problem was far simpler—she had only two theatres to consider, East and West.

The result of want of money and uncertainty as to what information would first be required was that we had only some general descriptions of possible theatres of war, and some route books of Belgium—called " Roads, Rivers and Billeting Reports." These contained hardly enough information for the G.S., and quite insufficient for R.E. work. There was no detailed information, on which engineers could work, of the nature of the waterways, the bridges (though some dimensions were given), nor what is more important, of the banks and approaches near existing bridges ; nor plans of the gas and electric power supply, the telegraph and telephone systems; nor data of the engineering works, supplies of engineer material, timber, road metal, etc.

I will give you an example of the information provided in the Route books—it is the worst specimen I could find, I quote it not for the sake of making fun of it but because there is generally much more to be learnt from mistakes than from successes.

The example is:—" From N. to G. a broad granited road was being constructed in 1913, with a stone bridge over a stream immediately south of the latter village. From G. to P. there runs a granite metalled road in bad repair in 1913, scarped in wooded cliffs on north side."

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"G. Population 1508. Post office, telegraph office near station, telephone office. Steam tram to L. Pipe water."

"To oppose hostile advance :—

Artillery position near B. Infantry in forest on western side of gorge. Forest difficult for movements, even for infantry. Destroy bridge and block roads into gorge."

I may say, as you will have guessed from the phraseology, that no R.E. Officer collected and recorded such indefinite information. Of course one wants to know how broad the road was; where there was metal to mend the road in bad repair; whether the stone bridge would take heavy traffic; how it could best be destroyed; details of the stream; where the pipe water came from; and what the delivery was. The moral is don't waste money by sending unqualified officers to reconnoitre, and rather record a few accurate details than generalities.

To turn to another example :—

Wishing to find out something about the river Meuse, I looked at the index of the route book, which gave page 2. I turned to page 2, and found it formed part of the "Contents" section. The book began at page 8. Turning over the pages, however, I found a second page 2 in the middle of the volume, but it only described a road. The only mention of the Meuse was

"Observation points (*a*) crest of ridge 1½ miles south of Anseremme: good view of Lesse valley and heights on left bank of Meuse."

I looked up in the index Givet, which is on the Meuse, in order to get on the track. Opposite it was a blank, no reference page given, though the name was there. So I turned up Dinant. The reference (page 13) was there and referred to "route F_3." I found "F_3," but nothing about Dinant. Then I noticed that I was looking at "F_3 side road g." After much turning over pages I found "F_3 main road," reconnoitred in 1911 (time of year not stated). There was Dinant all right described as "a great tourist centre, many hotels." A list of them was given, with garage accommodation. And I noticed, "For details of bridge over river Meuse; see Volume II."

Volume II. had no index, the key map showed no rivers at all. The "Contents" did not mention Dinant or the Meuse, and there was apparently nothing about them in the volume. However good intelligence is, it is useless if one cannot find the matter readily. A good key map with reference numbers should have been provided, as Bradshaw gives for railways.

Eventually I did find something about the Meuse. It was in a military report on Belgium and the Grand Duchy of Luxembourg. It contained this valuable military information :—

"River Meuse. Its current is swift in many places, while its

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depth is sometimes as much as 45 feet." There was no hint that the great Givet–Namur reach is sometimes fordable at places in summer, or that at the end of the winter blocks of ice come down it and carry floating bridges and weirs away; that piling is impossible above Namur on account of the rocky bottom and boulders, but can be used below that fortress. It would have been far better to have recorded "no reconnaissance of the river has been made, the few facts recorded here were taken from a school geography."

Needless to say that Sir G. Macdonogh, who became head of the Intelligence of the B.E.F. on mobilization, was not responsible for its collection before the War. The gallant officers who gathered the above no doubt did their best with the means at their disposal, but I think they should have refused to compile a book unless given the means to make one that would be of service.

Supposing we had the money, how should Engineer Intelligence be collected and how can it be done most economically? It is obvious that detailed information of an enemy's country, except what can be obtained from the air, can only be got in peace time. A great deal can be learnt from books published for commercial and scientific purposes, and from technical periodicals. Thus many details of the Rhine, for instance, were to be found in a navigation handbook for barges that was on sale. But as a rule more than is published is required for military purposes. Very often professional and business men can help to fill gaps. For instance some months after the war commenced we got a mass of geological information for tunnelling and water supply from the School of Mines in Jermyn Street. A gentleman interested in motor boats provided us with details of the Belgian and German canals. A military staff to do all the collection work is of course out of the question. Much of it can be acquired only by long residence in a country, but it should be known what is available and where it can be found.

Germany's methods may be of interest to you and throw some light on certain methods of collection. There were permanent agents residing in the coast districts of England, who with assistants, no doubt specialists, sent to them for a stay of three or four months, systematically collected and no doubt recorded information; but it would seem that every engineer and intelligent person who travelled was made use of, and only certain work was carried out by official reconnoitrers. I will give you some instances:—

A Professor of Berlin University came over to a scientific gathering at Edinburgh. He said to his host:—"I am told that there are some very interesting cliffs near Rosyth. I should like to take a car and photograph them." His host said: "Rosyth is a naval base, photographing near it is forbidden." "Ach so," said the Professor, "I did not know that; might I make a little pencil sketch?" His host demurred and the Professor asked if he might

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only see the place. Then his host told him he could not take a foreigner there.

Directly Hither Green Junction was opened a high German railway official asked if he might be permitted to inspect it as he heard that it was the latest thing in junctions. One of two Germans staying in Canterbury for Canterbury Week showed his host—after dinner—a map on which he was marking the water supply arrangements in Kent. Another party sailing on the Norfolk Broads were seen measuring the railway bridges.

This sort of petty spying is not congenial perhaps to the British temperament, we cannot expect this sort of help from our countrymen, but information can nevertheless be obtained through engineering firms, shipping and railway companies, etc., who have relations with persons on similar work abroad and know, at any rate, of the publications dealing with the subjects in which they are interested; and with this preliminary information a specialist will pick up much in a short visit to a district. As regards fortifications the general lay-out can of course be photographed from the air after commencement of hostilities, but details can only be obtained during construction through workmen. However, that is a matter for the Secret Service. The moral is, when you are building fortifications take note whom the contractor is employing. During the construction of the Metz forts by the Germans there were Frenchmen (Alsacians) among the workmen.

One of our great difficulties before the war was that there were very few English living on the continent who could be employed to get information. There was no one living in Borkum or at Cuxhafen, for instance, though there were Germans on the Isle of Wight and at Harwich.

The Germans undoubtedly made full use of some of their Consuls to collect information. When a General Staff officer was giving a confidential lecture to Territorials at a certain port, it was suddenly discovered by one of them that the local German Consul was present. Another was caught taking soundings from a boat with a fishing line, and a member of the German Embassy was detected in a dinghy at one of our disembarkation practices.

Our officials are different. I approached a certain Government official with a view of obtaining assistance to get information before the war. The meeting reminds me of Mr. Dooley's description of the visit of the Boer delegates to the State Secretary at Washington with a view to intervention in the South African War. Mr. Hay is represented as saying:—

"Go back to that great and good man, your President, and say that you found sympathy exuding from every pore, marked 'Private.' My heart beats for you, but not in official hours."

I got no help, British officials seemed afraid of touching anything

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in connection with a future war. But with Lord (then Mr.) Haldane's assistance, at any rate as regards Home Defence, matters gradually improved in this respect in the half dozen years before 1914. The point we must bear in mind is that to get good engineer intelligence in peace, it is essential to keep in touch with the official, scientific and commercial worlds.

Every Engineer officer however not only when he travels but even round his own station should make a point of noting engineer information, if only for practice. Even whether a railway line is single or double, the width of a road, may be of value later on. And don't forget to record the season of the year at which the observations are made. I think I am right in saying that we knew nothing about the effect of winter in Flanders, *e.g.*, the rise of the water table, of the subsoil water, in winter, though one of the causes of the French defeat at Blenheim should have put us on our guard. Some of you will no doubt think out what special information will be required in the next war, when perhaps all transport will be by tanks, and the nature of the river bottoms may be of interest. Perhaps we ought to know the colour and nature of the fields so that we may prepare our camouflage material to suit them.

No arrangements were made to collect engineer information about Germany, still less about France. We only had the books about Belgium of which I spoke. It was assumed that the *2e Bureau* would provide us with all that kind of thing if we ever went to war. But for the same reason as ourselves, want of money, they had very little. So don't depend on an Ally. Some little books of a series called *Notices descriptives et statistiques* were served out to us. They contained mainly information that would have been useful on manœuvres. They didn't tell us for instance, that three-quarters of the roads in N. France were closed—*Barrières Fermées**—during a thaw, nor that all the road metal in Northern France came from Belgium. None of these handbooks, moreover, were of recent date; and the 80,000 maps of France first supplied to us contained no military information, and had not been revised for many, many years. As some of you may remember, we were served out in August, 1914, with a map that didn't show the Canal du Nord, nor the causeway, road and railway across the estuary of the Somme near St. Valery, the meadows there were shown as sea even on the 100,000 map issued in 1915; and no one had warned us to learn to read vertical hachured maps.

The Engineer-in-Chief—or as he was called in August, 1914, the Brigadier R.E.—had no staff for the purpose of collecting engineer intelligence. Brig.-General John Tanner, Chief Engineer of the

* These words when placarded over the country indicated to the farmers that their heavy wagons were restricted to certain high roads. In the past possibly the minor roads were actually closed by a barrier.

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VII. Corps, said to me only a few days before he was killed in 1917—*à propos* of the lack of engineer transport—that the R.E. was a head and body without legs; I added that the head was at first without ears. In fact the B.G.'s staff consisted of one clerk, and he himself had to share a motor car with the Artillery Adviser; hardly a suitable arrangement, because the work of the A.A. and the B.G. R.E. seldom took them to the same place.

General Fowke in the course of time commandeered various officers, and in October, 1914, I joined his staff. As I always had a predilection for collecting information, useful and otherwise, I began to busy myself to see what could be done to organize Engineer Intelligence. The C.G.S. was specially interested in Lille (as we were opposite to it), Antwerp and inundations. So I commenced on these. The matter is of interest as showing that care must be taken to have information about one's own country available, and to know who have it in their charge. I was directed, as a first step, to visit a certain French General. His staff had no engineer information, but the Engineer-in-Chief of the *Région du Nord* at Boulogne, who some years before had been Chief Engineer of Lille, was said to have complete records of the Lille defences, etc. At Boulogne nothing could be found. It was supposed that the plans and papers must have been left behind when Headquarters of the I. Corps District hastily evacuated Lille. This officer kindly made me some rough plans and sections of the forts. It was suggested that I should try the *Section Technique* in the War Office, Paris. So there I went. Numerous ancient documents about Lille were unearthed, some signed by Vauban himself, but no plans or details of the existing forts. However, I was introduced to the Municipal Engineer of Lille, then a refugee in Paris, who gave me a good deal of information and prepared maps showing the water supply and all important details of the town, and also much about the country round; and he put me in the way of obtaining information generally through the Civil Engineer administration of France, the *Ponts et Chaussées*, which has an Engineer-in-Chief in each Department.

The moral of this is, study the Civil Engineer organization and administration of a country in which you expect to wage war, even your own, for I remember in 1911 at the time of the railway and dock strike, having a great chase to get a large scale plan of the London Docks, showing the entrances and the nature of the boundary walls and fences.

By not going to the right officials, the officer who compiled the water book for the Army manœuvres which should have taken place in 1914 made an important omission: he left out all mention of the great mains which convey water from Lake Vyrnwy in Wales to Birmingham, and which actually ran across the manœuvre area. When the D.A.Q.M.G. and C.R.E. of my Division went down to

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prospect for camps they smelt them out and found that to supply the camps they only had to tap into these pipes.

There is a further lesson with regard to one's own country—although the French and Belgian *Ponts et Chaussées* was extraordinarily well organized, and staffed by engineers who all had had military training and were reserve officers, not one of them seemed to have considered the department of which he had control from a military point of view. For instance, they knew how to drain marshy areas, but not how to flood them.

However, as we were in an Allied country, it was not difficult gradually to collect and codify a great deal of information obtained from the engineers of the *Ponts et Chaussées*, both French and Belgian. We learnt gradually that the *Maires* kept large scale cadastral maps, useless in most cases since not revised since 1826, and that the Army had excellent up-to-date maps called *Plans directeur*, not of course on sale ; and that there were half a dozen or more zero points of the levels on maps.

In the middle of 1915, I was switched off to other work, and Major-General Sir W. A. (then Colonel) Liddell started the organization of Intelligence on a larger scale, and it is to his forethought that we not only had the requisite information when the Germans fell back in 1917, but that we had the bridging, road, and water supply material, etc., to cope with the situation. He had the assistance of only two officers, Captain Sheppard, R.E., and Captain King, a geologist from the Geological Survey.

I would particularly direct your attention to the form in which the information that he collected was made available. It was mostly on maps. There should of course be a full record printed, but the essential information, to be readily available for use, must be graphic. A few simple conventional signs indicate at a glance the class of road or bridge, places where road metal can be found, water supply, etc. ; suitable areas for well sinking and dug-outs, etc., I remember that the Gunners complained that the coloured maps issued showing where good, bad, and indifferent dug-outs could be expected did not show the condition of the soil at the surface. So remember to make quite clear what information the map supplies.

Early in 1916 a change was made in the organization of Engineer Intelligence ; the B.G.G.S. "I." G.H.Q., who was himself an Engineer Officer, came to the conclusion that part of Engineer Intelligence belonged to him. He took over General Liddell's practically complete work and Captain Sheppard with it to finish it, but then owing to pressure of work had, as the War Office would not authorize an addition to his staff, to convert Captain Sheppard to ordinary Intelligence uses. The moral is :—Don't trust a brother engineer if he is on another job to do engineer work for you : keep an eye on him. The convention of the division of labour was that

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G.S. " I. " was responsible for engineer information in front of the British line, the Engineer-in-Chief for anything behind it. As regards the G.S. " I. " share, Armies were responsible for the ground ten miles—I think it was—ahead. G.H.Q. for anything beyond. This definition was, of course, satisfactory, but " I. " and " E. " must always work together.

Meantime, the Engineer-in-Chief's staff had been slowly growing. General Liddell found it necessary to bring in some specialists : for Bridging (Captain Hopkins, N.A.), Machinery (Lieut.-Colonel Du Cane, N.A.), Electrical work (Major Rich, T.F.).

As tunnelling ceased after Messines, Lieut.-Colonel and Professor David, F.R.S., of the Australian Forces, became available for general geological work. As regards specialists it is important to keep one's eyes open so as to get hold of the best. I may interpolate what Lord Wolseley said to me once : " Keep a notebook and put down the name of any good officer you may hear of and his qualifications. The time may come when you may want a man for a special job. It is no good going to the Military Secretary ; he doesn't know one officer from another. You might as well go the Army and Navy Stores."

When General Liddell went to be C.E. of the First Army and I resumed dealing with Engineer Intelligence of the theatre of war, I found that there were really hands available to cope with the details. Soon afterwards the Engineer-in-Chief, General Heath, added to his staff a special officer to study inundations.

A new head of the Intelligence, the third R.E. officer (the late Brigadier-General E. Cox), took over and fresh arrangements were made with him. He managed to get authority to add two officers to his staff, both R.E. officers, to give their attention mainly to Intelligence of the country ahead and to do *liaison* with the Engineer-in-Chief. All Engineer information that came in was passed to the Engineer-in-Chief, and he was also warned when prisoners or refugees who could give information were available. On his side the E.-in-C. nominated one officer of his staff as the connecting link with " I." The E.-in-C.'s specialists examined the information obtained, prepared it in a suitable form for publication, directed " I.'s " attention to what further information was required. Thus " I. " and " E. " worked together, and did each his own work. It is obvious that Engineer Intelligence is not a whole time job for any particular specialist, but all the same " I. " must have this assistance.

On the other hand " I." alone is in a position to find out the changes behind the enemy's front. Peace information may not hold good—bridges may be destroyed, roads widened, railways torn up, water supply, etc., improved. " I. " of course is the proper authority to issue intelligence.

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This system worked admirably at G.H.Q. and was partially applied in the Armies. It would appear that, in addition to the collaboration of "E." and "I." at G.H.Q., there should be an Engineer officer on each Army Staff—it really doesn't matter whether he is labelled "I." or "E."—who should be specially on the look out for Engineer Intelligence.

The Engineer-in-Chief had a great piece of luck, as four of his specialists happened to know German well. I hope that the present generation of young officers are better linguists than mine were; the Intelligence throughout the War was embarrassed by want of officers who knew military German and military English. Intelligence work cannot be done without a knowledge of the enemy's language. I might draw your attention to one little matter. New foreign technical words are rarely to be found in dictionaries, so specialists in Engineer Intelligence should provide themselves with the latest text-books of their subject in the language of the country in which they are interested and learn the new words as they occur. They should make a vocabulary of them for the benefit of their successors.

So much for intelligence about the theatre of war.

I now come to information about Military Engineering, the collection and dissemination of Intelligence with regard to the enemy's methods and the results of our own and our Allies' experiences. As regards the enemy—this also must be begun in peace time—you may say that we shall learn all about the enemy within a few weeks of the commencement of the war. This in a way is true, but as a fact we did not know many Engineer details until the Boche was driven back in 1916 and we began to capture documents in large quantities. Besides learning during war is always an expensive process. The German text-books of Field Fortification, Explosives, Mining, Bridging, etc., were all on sale before the War. When I was in the German Section of the Intelligence they were sent regularly to the S.M.E., but almost invariably came back, with the request that they might be translated, which was unfortunately impossible, owing to the time and labour involved. There was no difficulty about studying the German methods, no objection was raised to British officers being present at German Engineer manœuvres. There was a very full printed English report of an accelerated (manœuvre) attack on the fortress of Ehrenbreitstein in 1908, at which the methods of trench warfare were employed, from digging in on ground gained to going over the top. Loop-hole shields, periscopes, sniper's suits, light ball pistols, and even hand-grenades were used, the last represented by model sandbags which the men threw at each other. I don't think that many officers read the report, as it was of course marked "confidential." I have never yet seen the German *Feste*,

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the super fortress, described in English. The Editor of the *R.E. Journal* and the new R.E. Board may perhaps, in future, be able to keep us up-to-date as to the Engineer methods and Engineer text-books of foreign Armies.

As regards intelligence of German military engineering during the war, a system grew up gradually, but it was not fully working until 1916. An arrangement was made between "I." and "E." that all documents and secret information received by "I." with regard to enemy field defences and engineer apparatus should be passed to the Engineer-in-Chief, who then advised whether it should be published at once in the Daily Summary of Information, or in a series prepared at greater leisure called "German Field Work Plates." Thus, a sketch of the German silent delay action fuze went out at once, pictures of dug-outs went into the general series. Translations on Engineer subjects were similarly selected. They were made by "I." and checked by "E." before publication.

The responsibility for information with regard to captured defences, which required engineer knowledge to measure up and draw, rested with the Engineer-in-Chief, who made the necessary arrangements through R.E. channels. Thus, after the capture of Messines, the R.E. collected all information possible about the Pillboxes. Much information of this kind was obtained on the initiative of C.R.E.'s and Field Company commanders; without their help little could have been done; but there must be someone at Headquarters to collect, collate, and disseminate. There must be someone too to look ahead and see that experiments are made or data collected to supply information which is likely to be required. For instance, the effect of mobile charges of various sizes on dug-outs, the comparative value for building cover of monolithic concrete and blocks.

Information as regards our own and Allied methods, experience and experiments, was collected by the Engineer-in-Chief, and issued in various series :—

1. Plates of field work designs (simple plates).
2. Field work notes.
3. Mining notes.
4. Domestic plates of huts and camp accessories.
5. Stores circulars.
6. Standard bridge drawings.
7. Articles made in R.E. workshops.
8. Miscellaneous.

Full lists will be found in the *R.E. Journal* of February, 1921.

It is best to send out such matter with serial numbers, so that those who read them may keep them together and notice if they fail to reach them.

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An important question is how far should such information be distributed. It is a mistake to overwhelm officers in the fighting line with too much paper. It seems to me that it need not go beyond C.R.E.'s, and that they should have spare copies which they can issue if necessary. For some cases it is best to send out a small sketch and say working drawings are available if required. I am afraid that the lists of information issued, which are given in the *R.E. Journal* for February, 1920, look formidable, but the Engineer-in-Chief had to consider the Training Schools in France and at home, and other theatres of war, which were all clamouring for the results of experiences in France. The number of copies sent home rose from 1 to 200, to 500, and finally to 800. The usual method of issue in France was to send a proof to the C.E. of each Army, who then said how many copies of each, if any, would be required. Thus the C.E.'s controlled the issue in the Armies.

To save bothering fighting units with paper, a good deal of information can be passed on by C.E.'s and C.R.E.'s verbally—it saves everybody's time. I remember that when Major General Sir C. Fergusson was Inspector of Infantry he seldom came round to the Division that I was then in without telling us of some good device or method that he had seen in another division, and this always seemed an excellent arrangement. Besides, it made us look on him as a friend, instead of a critic.

The notes, etc., should be printed in a compact form, not foolscap size—which the Stationery Office love—but on sheets 7 by 3 inches, punched with three holes, so that they can be put in a cover or loose leaves. Each officer can keep the sheets that he thinks he may want. The Americans used this system.

One further point requires notice, G.S. "O." are responsible for the issue of training manuals. The Engineer-in-Chief must therefore keep in touch with the Editing Branch, so that the G.S. publications intended for the Army generally contain the latest Engineer views. The special R.E. training manuals were of course written in the E.-in-C.'s office and then passed to G.S. for approval. For the material for the manuals the E.-in-C. was dependent on C.E.'s and C.R.E.'s sending in, or supplying when requested, reports of the latest methods.

The best course is for the central authority to compile, and then send out the type-script to be read by selected authorities. The officers who know most rarely have time to write, but can find time to check other people's work.

To conclude. If we are to make Engineer Intelligence a success in future, we must keep in touch with our civil brethren and with the scientific world. The new R.E. Board will no doubt help us much. But all must bear a hand. Every officer ought to know one language besides his own. Remember Lord Kitchener got his

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start in life by being able to speak Arabic.* In the late War, Germany fortunately gave us time in 1915–16, by attacking Russia and then the French at Verdun, to shake ourselves together and consider our problems. Next time we may not be so fortunate. We should have been in a bad fix had we, for instance, run up against the great excavation of the Canal du Nord in our retreat in August, 1914, when we had nothing more than pontoons and trestles with which to bridge it.

* The story was told to me by Major-General Hon. E. Stuart Wortley. He was, in 1882, Military Secretary to the Sirdar, and busy collecting officers for the new Egyptian Army. Kitchener called to see him, to get employment, but unfortunately too late, as all the appointments were filled up. When he was told this Kitchener said "I ought to add that I speak Arabic," Stuart Worthy said "That makes a difference, I will speak to the Sirdar." A job was found for him. It was as an Intelligence Officer that he first made his name.

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AEROPLANE PHOTOGRAPHIC SURVEYING.

THE DEVELOPMENT AND PRESENT POSSIBILITIES OF AIR PHOTOGRAPHY FOR MAPPING.

By LT-COL. H. ST. L. WINTERBOTHAM, C.M.G., D.S.O.

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DURING the war a great impetus was given to this latest method of survey. From balloons, or kites, air photography had been gradually evolving for 70 odd years, but the introduction of photography from airships and from aeroplanes, combined with the necessity of mapping inaccessible areas, led to the extensive use of air photographs for the revision of existing maps and for the detail survey over triangulated areas. The actual sphere of usefulness and limitations of the air photograph do not seem to have been grasped, however, by many more than the surveyors and some of the photographic staff employed on these war surveys. Even to these few the economic possibility of the method is still an uncharted region, for no statistics as to cost were kept, as far as I know, and as a consequence many extravagant claims as to the possibilities and economy of aerial photography for mapping have been made.

The present article is an attempt to outline, in two parts, the development of air photography as a survey method and the stage it has now reached.

PART I.—THE DEVELOPMENT OF AIR PHOTOGRAPHY FOR MAPPING.

Pre-War History.

The idea of replacing the personal work of the surveyor and topographer by photo-mechanical means dates from the time when both balloon and camera became available. We have literature on the subject which covers the last 70 years, and a fair measure of success was secured even before the war.

The camera, of many different designs, sometimes single, sometimes multiple, was used at lowish altitudes from fixed balloons or even kites. A recent German publication states that such a system had its first application in war at Solferino and its next at Richmond. Now the balloon does not lend itself to the taking of a series of plates

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more or less parallel to the earth's surface. This is obviously impossible if the balloon is stationary, and when it is free its movements are naturally erratic and more or less unforeseen. Photographs taken for mapping purposes were then taken obliquely at an angle of dip (below the horizontal), of something of the order of 30 deg. in order to cover as much ground from a single station as possible. The actual position of the balloon in space was easily enough determined either by intersection from ground stations or by photographing a base in the form of a cross (of known dimensions) immediately below the balloon. These early experiments were very widely distributed—French, Americans, Russians, Germans, and Austrians all taking part. So far, these oblique photographs were regarded as perspective views of flat ground. No corrections could be made for difference of height or ground form. Towards the close of the last century a big stride was made by the introduction of photogrammetry from the air, whereby ground forms and contours could, theoretically, be dealt with, although practical success can hardly be said to have been obtained. Between 1905 and 1914, however, renewed progress was made, and special instruments were manufactured by Zeiss, both for photography and for measuring angles upon the developed negative or upon contact prints. It may be said that mapping of both detail and contours from oblique photographs was now practically possible, but that the calculations necessary were too cumbrous and involved to hold out hopes of economic success. These latest developments were, I believe, entirely German or Austrian. It will be seen, then, that on the outbreak of war the Central Powers had secured a substantial lead.

War Experience.

It is probable that photography from aeroplanes (as distinct from balloons) had reached the stage of development at which it began to be of use to the map-maker quite early in 1915 in all the larger armies. The first photograph used for mapping purposes by us, for example, was one of Neuve Chapelle, taken immediately after the battle. French and British methods developed side by side, and naturally took on the same complexion. German methods, influenced by their pre-war experience and hampered by the Allied command of the air, were somewhat different. In each case, however, progress was governed by some common factors, which should be enumerated.

In the first place, air photography was not begun, in the war, for mapping, nor was it, except in rare circumstances, ever exclusively directed to that end. This fact had a great influence upon the development of mapping from air photographs, because the surveyor was not consulted in the design of camera, or in the methods of photography.

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Secondly, the airmen were never able to give up much space to the camera and its fittings, because they had to carry so much armament, and were seldom allowed by enemy aircraft, and by anti-aircraft guns, to give their whole attention to photography.

These two factors were responsible for the fact that British surveyors made few special demands upon the airmen, and were content to take whatever photographs were supplied without further ado than to ask for some lenses of a shorter focal length than was usual for intelligence work, in order that larger areas might be covered upon a single plate.

Still more important in its bearing upon our methods of mapping from air photographs on the Western Front was the existence of a fairly universal trigonometrical framework and a fairly complete series of cadastral plans at a large scale. No doubt the Allies were here in a happier condition than the Germans, but it was in the main true that all mappers on the Western Front had a skeleton ready to hand, and wanted only a photographic field sheet, as it were, and not a photo-theodolite. It is in the development of an oblique photography, or of photography on a vertical plate, and of angles measured by its aid, that progress must be looked for in determining the positions of additional control points, but it is to the photograph taken vertically downwards (*i.e.*, a horizontal plate) that one naturally turns for the amplification and correction of detail, and such photographs are obviously procurable if the aeroplane can fly over all the country to be mapped. One further item must not be forgotten; neither the French, Italians, Americans nor ourselves were as far advanced as the Central Powers in the possibilities of photogrammetry from the air, nor did we possess the instruments necessary to its development.

We relied then upon the trigonometrical framework, and upon the detail survey of Napoleon's time, for position and accuracy; upon topographic maps and bench marks for contours; and upon photographs taken as nearly as possible vertically downwards for topography. Now experience soon showed that very few photographs were taken truly parallel to the earth's surface, or were, in fact, a correct representation of topography. The aeroplane was almost invariably tilted at some slight angle to the desired position, and the camera was, as rule, rigidly attached to the fuselage. Other small distortions due to shutter or lens were not unknown, and very occasionally, on the Western Front, ground forms were sufficiently marked as to introduce error. In the main, however, the only error of sensible proportions was due to the tilt of the plane. On the other hand, a high standard of accuracy in our maps was called for and was obtained, and the distortions due to the perspective effect of photographs had to be overcome in various ways. It is usual now to speak of the "rectification" of a photograph in

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describing the methods employed to bring the perspective picture to the desired plane. The methods of rectification evolved on the Western Front are very ably handled by Lt.-Col. MacLeod in a pamphlet recently published by the War Office, entitled *Mapping from Air-Photographs*. They need no description here, for although it is important to realize that nearly every photograph has to be rectified in some way before it can be used for mapping at large scales, it is immaterial for the purpose of this article to go further into detail.

It will be necessary now to leave the Western Front, and to consider the problem confronting the map-maker on one of the less civilized fronts, and it will be convenient to choose Palestine, because we have full descriptions of the methods evolved there from the pen of Mr. Hamshaw Thomas, who was himself largely responsible for the excellent results obtained. Palestine had, luckily enough, been surveyed on behalf of the Palestine Exploration Fund, by Kitchener, Condor and others. The resulting map, at the scale of one inch to the mile, was not of a modern order of accuracy, nor did it show much detail, but was fairly reliable as to the positions of towns and hamlets. As a framework for this new map, then, the surveyor in Palestine had the triangulation upon which the Palestine Exploration Fund's map was based, and the positions of towns, etc., as shown on the map. It will be seen that there was no universal and large-scale skeleton upon which each photograph could be identified and rectified, like that supplied by the cadastral maps of France, and that sequences or traverses of photographs had to be considered as a whole, and scaled off between control points. On the other hand, there was much less actual warfare in the air, and pilots were able to give more undivided attention to photography. Moreover, as the surveyor had been unable to anticipate the demand for good maps, the subject assumed such importance that special measures were taken to photograph for mapping, as distinct from intelligence work, and special training was given on the subject to pilots. It is natural, then, to find air photography playing a more important rôle here than on the Western Front, even though, broadly speaking, the use it was put to was the same. In both cases air photographs, whether used singly or in strips, filled up blank spaces in the topography between trigonometrically fixed control points. The differences were in matters of detail, but are of interest none the less. In order to bridge the longer gaps in the controlling skeleton and to make up strip mosaics or traverses great care had to be taken to keep the camera as nearly as possible in a vertical position. It was found that by putting pilots through a thorough course of instruction a great advance was made in this particular. It was also found that when flying as steadily as possible the spirit-level was a great help in eliminating tilt, although it could not, naturally, be relied upon

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implicitly. These two factors enabled the surveyor to reach so fair a degree of accuracy that for his one in 40,000 scale it was unnecessary to "rectify" each photograph, and the photo-traverses were pasted on to brown paper and then photographed up or down to the correct scale. So comparatively well did this photo-traverse scheme work, that where there were particularly few trigonometrical points, additional control points were fixed by flying over and photographing the sides of triangles, and thus fixing the position of the apices, just as the detail surveyor does by measuring the sides of triangles with his chain. A further point of interest lay in dealing with the distortions due to the steep and hilly inland areas. Wherever you meet with differences of height on the ground you must get differences of scale on your photograph, for the scale depends upon the height of the camera above the ground, and we get a certain amount of displacement which can best be understood by taking a concrete case. Supposing we take a photograph from a camera held rigidly vertical, nearly, but not quite, over some factory chimney. The ray from the lens to the top of the chimney, then, is not absolutely vertical, and if prolonged to cut the ground will fall to one side of, and not over, the base of the chimney. Now nothing that one can do to the resulting photograph will put the top of that chimney in its right position in plan, but the displacement becomes less as we get nearer to the centre of the photograph.

It is partly because of this trouble, due to differences of height, and partly to the trouble of tilt, that experience led surveyors to use no more than one-third of each photograph and to arrange for a correspondingly larger number of exposures.

One more point of interest from Palestine (and Mesopotamia) is that air photo-topography proved most valuable, as one might have foretold, for mapping large Eastern towns, with their tortuous and narrow streets.

We may now sum up the experience gained by us in the war.

Firstly, we invariably had a network of triangulation on which to base our new surveys, and sometimes we had reliable old cadastral surveys also.

In the second place, all photography for mapping was done from a camera held as nearly vertical as possible; but

Thirdly, we had failed to evolve any means of holding it absolutely vertical, and practically every photograph was sensibly distorted in consequence.

Fourthly, we mapped at scales which varied from 1 to 6 in. to the mile. At the larger scales every photograph had to be rectified, and at the smaller scales, after considerable training of the pilot, it was found possible to use photo-traverses.

Fifthly, we dealt with the problem as if the earth were flat (a safe assumption in Flanders!), and we evolved no method of actually

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measuring differences of height or of contouring, although we made use of the stereoscopic effect visible from two photographs which were partly of the same area.

In short, we had made it a quick and efficient, though not necessarily a cheap, method of detail survey at medium scales, but had in no way made it possible to dispense with the trig. observer or the contourer.

Our British experience is probably representative of that gained by the Allies in general. Indeed, German methods and achievements followed on much the same lines, with this essential difference—that they did occasionally employ photogrammetric methods from the air, and were able to contour inaccessible ground to some extent in consequence. We know this from articles which have appeared since the war in German surveying papers, but I am bound to say that one could not have suspected the fact from an examination of German war maps. It is probable, too, that much of the German mapping of our trenches and of the area in our occupation was done from oblique photographs.

Post-War Experience.

The important problems confronting the air photo surveyor of to-day have resulted in a good deal of research but little practical advance as yet. There are, however, three post-war air surveys of interest to mention. Most interesting is a survey carried out in North Africa by the French. The problem confronting the surveyor in this instance might occur frequently in war. The French outposts ran along the edge of a very mountainous, difficult, and hostile country, which could not be entered by surveyors. It was desired to map a strip of 60 kilometres broad. Triangulation had been pushed up to the outpost line. The programme of work may be considered under the headings :—

Additional trig. control : Fourth order.
Air photo-control : Fifth and sixth orders.
Air photo-topography.
Air photo-contouring.

The first stage was to intersect with the theodolite a number of peaks, and these are classed by the French as the fourth order of control, and serve as the base for the fifth and sixth orders. To carry out these further controls planes ascended nearly, but not necessarily quite, over trig. points, and took panoramas as nearly in a vertical plane as possible. These panoramas included various already fixed peaks, and the position of the camera at the moment of exposure was resected from these known points. The positions of exposure were then plotted and forward rays to other points were drawn in. By repeating these panoramas at a variety of points and

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at different altitudes a number of points of the fifth order were established. Points of the sixth order followed in much the same way, but with the difference that they were intersected by rays measured on panoramas taken during flights over the ground to be mapped, in conjunction with the air photo-topography, and corresponding to marked horizontal plane photographs. The photo-topography was done on a cinematograph film, exposures being governed mechanically, and the result, controlled by its sixth order interpolations, was plotted from compiled and mounted photo-traverses. Here we see, then, a further development of Hamshaw Thomas's traverse scheme. Finally, heights were calculated from the plotted distances, and from vertical angles measured on the vertical panoramas, starting from the height as given on the barograph in the aeroplane. It is noteworthy that no claim is made of an accuracy greater than that wanted for a survey on the 1 in 200,000 scale, and it is probable, I think, that errors in linear measurement between control points are of the order of 1/500 (which may therefore reach a sensible total), and errors of altitude of the order of ± 100 ft.

Quite recently, in an Engineering Supplement of *The Times*, we read of American experiments in air photo-hydrography and air photo-topography. Little progress seems to have been made in the former, for it was found that contrast in tone on the photograph did not correspond necessarily to relative depth, but followed more generally the colour of the bottom.

The air photo-topography, however, proved its value in the revision of a coastline strip, which was chosen as one of the natural subjects for this method. Here again we find the air photo-traverse employed without rectification of the individual photographs. A noteworthy feature of this survey is the reliance upon a camera controlled by gravity and fitted with spirit-levels—which adds another confirmation to the soundness (within certain limits) of our war procedure in Palestine.

The third and last survey to mention is one reported in a German work on photo-grammetry from the air. A party of trig. observers preceded the photography and fixed an additional number of points in the area in question, and another survey party named, and revised on the ground, the plotted map. Air photography was entrusted with the fixing of additional points from the measurement of horizontal and vertical angles on negatives taken obliquely, with photo-topography partly from these obliques and partly from horizontal plane photographs, and with photo-contouring.

The most interesting feature of this survey, and of the literature which deals with it, is that it establishes definitely that the position (and height) of exposure in space, and the direction and magnitude of tilt, can be fixed easily enough if three known points appear on

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the photograph, and it describes instruments for calibrating the lens and for angular measurement on the negative (which is tilted to correspond to its position at the moment of exposure).

PART II.—THE PRESENT POSSIBILITIES OF AIR PHOTOGRAPHY.

It will be convenient to a *résumé* of the subject to adopt the following headings and to omit an unnecessary repetition of the prefix "air."

1. Photo-control.
2. Photo-traverse.
3. Photo-topography.
4. Photo-contouring.

1.—*Photo-Control.*

All previous surveys have emphasized the fact that photo-control cannot give an adequate support for a map, except for short distances. It may follow either from oblique or from vertical-plane photographs, and in either case, to be of value, from refined measurement on the plate. It postulates interpolation from previously fixed points appearing on the plate (and a determination of the magnitude and direction of tilt in the case of obliques). A high order of accuracy in measuring angles from photographic plates has been obtained for some purposes, but so far photo-grammetry has not given us much precision for surveying, and, with the added difficulties of resecting in space and then rectifying it is not to be expected that the error of linear measurement will fall below something of the order of 1/500, if indeed it falls so far. It is, in my opinion, highly unlikely that any graphic interpolation depending on geometrical construction or upon any mechanical device will give us results which will do more than hang two or three photographs together. To mention one point alone, the lens itself must be carefully calibrated, and the corrections which result to the position of points on the photograph may assume serious dimensions. In German practice the angular measurement on the plate follows from observation with a specially-designed theodolite looking through the lens used in the aeroplane (or one precisely similar) at the plate which is set to the actual angle of tilt.

At this present moment we have no experience in the provision of a photo-control, although the matter is in capable hands, and we may hope for speedy developments.

One may say at once, however, that no photo-control is likely to do more than amplify the trigonometrical control, or carry us some few miles from it, and that only where suitable and identifiable points are to be seen on the negative.

No photographic method will give control points in a forest, for example.

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2.—*Photo-Traverses.*

A photo-traverse is a form of control from the horizontal-plane plates, and has proved its utility, but it must be remembered that it can give accurate results only in flat country. Its value must depend largely on the previous training of the pilot and upon the vertical position of the optical axis. Now to ensure the latter we can, at present, do no better than hope for a steady "air-speed" and rely upon gravity and the spirit-level. It is suitable for scales smaller than 1 in 20,000. A gyroscopic attachment has often been discussed, and may yet appear, however, in which case greater accuracy may result.

3.—*Photo-Topography.*

With our control (and possibly traverses) plotted, we now turn to the detail, and here we must think in the first instance of scale. No photograph will give a ground plan of a thick hedge, or the boundary of a wood, or of a house with eaves, etc. It can, in fact, give only what it sees, and, as has frequently been pointed out, it cannot hope to give us cadastral plans whenever overhanging detail is met with. For large-scale maps (shall we say from 1/5,000 to 1/20,000) each photograph must, at present, be "rectified," but if we secure a good gyroscopic or other device for holding the optical axis vertical, we may escape this laborious step. Indeed, we must do so, on economic grounds, if photo-topography is to compete, over ordinary country, in the open market with the surveyor. For small scales and in flattish countries trained pilots have already shown us that "rectification" is unnecessary, except perhaps under war conditions. In Palestine the errors in position due to the hilly nature of the ground were assessed at a general figure, of about 70 metres, and one can see that special rectification must follow in mountainous country.

4.—*Photo-Contouring.*

To be of any accuracy, heights must at present be calculated from vertical angles measured on the plate and a previously computed height of the camera at the moment of exposure. Considerable calculation is necessary, but as a method it is feasible enough, and in the recent German survey, mentioned above, it is claimed that errors of height varied from one to two metres. It may become quite practicable to rely on stereo-photo-grammetry applied to two photographs "placed" on the detail and rectified, but we have no experience as yet in this method.

Finance and Summary.

Now, having discussed our various stages, let us turn to finance. One may assume that the taxpayer will remain indifferent as to which of his pockets the money comes out of. His chief preoccupation will be the gross total. It serves no purpose, therefore,

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to assume, as recent articles have done, complacent departments which may, by timely loans of men and material, diminish the apparent total.

I do not myself see how the price per plate can be less than 15s. or so, if we allow for expenses in rectification and in fitting to the map. It is, however, useless to elaborate this point here, for there are no recorded figures to show us exactly where we stand. We must await experience. We can say, however, with certainty, that except in certain extreme types of country we may economize in time, but are unlikely to economize in money. These three points will help to realize the position :—

1. The Ordnance Survey is a standing proof that cadastral plan at a scale of 1 in 2,500 can be surveyed at a cost of £12 18s. a square mile (pre-war figure).

2. Our pre-war Colonial Surveys show examples of fully completed topographical surveys at 1 inch to the mile for 10s. a square mile, and ½ inch to the mile for 5s. per square mile.

3. The inevitable preliminary to an air-photo survey is a triangulation and the inevitable sequel a visit to the ground for examination, naming, etc.

To sum up the present position we may then say :—

(a) As far as can be seen at present, air-photo surveys cannot give us cadastral plans.

(b) Medium scales (1 in 10,000 to 1 in 40,000) offer the most favourable sphere.

(c) There is no likelihood that photo-control can take the place of triangulation except within small areas.

(d) A visit to the ground will always be necessary for examination and naming.

(e) Photo-survey has taken its place as a method, and a useful one, but has not replaced, and does not seem likely to, except in special cases, the older methods.

(f) The Classes of survey for which air-topography is especially suitable seem to be :—

i. Where the ground to be surveyed is inaccessible to the surveyor.

ii. Revision for economic and statistical purposes where accuracy is not essential (*e.g.*, areas under cultivation, index maps to properties, etc.).

iii. Plans of large towns, archæological sites, etc., at medium scales.

iv. River channels, estuaries, and deltas, where shifting detail and difficulty of survey combine to obstruct land survey.

(g) Existing methods of air survey have been sufficiently exploited already to allow of a fair estimation of their possibilities. Progress will come most surely then from research

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and experiment directed upon the following (amongst other) points :—

i. The ensuring of the verticality of the optical axis.
ii. The measurement of magnitude and direction of tilt.
iii. Measurement on the plate of horizontal and vertical angles.

EXPERIMENTS IN AEROPLANE PHOTO SURVEYING.

By LT.-COL. S. F. NEWCOMBE, D.S.O.

A PROFESSIONAL Paper, No. 19, entitled " Experiments in Aeroplane Photo Surveying," by Major C. G. Lewis, Royal Engineers, and Captain H. G. Salmond (late Royal Air Force) has just been published by the Survey of India, Dehra Dun.

The experiments made were for :—

(*a*). One-inch topographical maps ;
(*b*). City surveys.

The aim of the experiment was to ascertain :—

(*a*). What standard of completeness and accuracy is obtainable in one-inch and City surveys in the plain ;
(*b*). The precautions necessary to give required accuracy ;
(*c*). Whether the method has advantages in time, cost, or results over ordinary methods ;
(*d*). The best arrangements to be made for carrying out big programmes in the future.

The City of Agra was selected as headquarters. The camera used was L.B. type with adjustable cradle. Lenses 8½ inch and 20 inch (for city work). The altitude decided on was 13,000 feet giving 3.5 inches to one mile. The cameras were fitted with 5″ by 4″ plates, the short side parallel to direction of flights. An area of 31 miles east and west, by 17 miles north and south, was to be covered (being the area of two one-inch sheets) by twenty parallel flights east and west, giving a centre to centre distance of ·86 mile and 40 per cent. overlap between strips. An overlap of 33 per cent. between successive photographs was allowed for, nominally one exposure every thirty seconds. Helios were located at the beginning, centre, and end of each 30 mile strip. ' T ' ground strips, the elements of which each measured 30 feet by 52 inches, were laid at each helio point. These were easily visible in the photographs. (In flying over Cairo at 6,000 feet, the lines of tennis courts are easily seen in the photographs.)

After describing the method of working the helios, Major Lewis says that the use of helios for various reasons proved very unsatis-

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factory,and that the cost and labour of the ground work would always be out of proportion to the benefits derived. He thinks it would be worth trying smoke bombs. The number of plates exposed was 1,757, but owing to various causes the number of negatives available for use was 1,495. Charts at the end of the book show the courses actually flown and area covered by negatives, and are instructive in showing how much room there is for error, and how unusual it is for a plane to keep an absolutely straight line. This would point (i.) to more special training for the pilot for the particular work; (ii.) to a cheap but efficient system of land marks to guide him, c.f. ground strips and smoke bombs; (iii.) to allowing more than 40 per cent. overlap between strips to avoid the necessity of extra flights to fill gaps; (iv.) to the use of a wider plate than five inches.

The Royal Air Force photographic officer had a very difficult task to get the large number of photographs mounted in strips with a very much undermanned staff. Attention is drawn to the necessity of very efficient numbering, and of using the best quality plates and paper; unless the photographs are excellent, they are of little value. The photographs were pasted down in strips on pieces of 4-ply Bristol board, and sent out to the surveyors for supplementary field work on the ground. Owing to difference of scale, it was not usually possible to make up mosaics of two or more strips, which would have been more convenient.

The supplementary field work comprised (*a*) pointing; (*b*) inking up on the photographs all detail necessary for 1-inch map; (*c*) preparing village lists; (*d*) colour traces.

The area was covered with points 1½ miles apart, mainly by plane table intersection, these points being given serial letters which were shown on the plane table and on each of the strips on which the point occurred. All necessary detail was inked up on the photographs in the usual symbols in black, red, and blue indelible inks. Heights of hills were obtained by the clinometer, and shown as relative heights. The average daily out-turn per surveyor was three square miles per diem, in fixing points and filling in detail.

Photographs may be brought to the scale of the mosaic either (*a*) by scaling individual photographs from the original negatives in an enlarging lantern, (*b*) by scaling strips of photographs made up of contact prints. Usually (*a*) would be used for enlarging the original photographs, (*b*) for compilations on a reduced scale. In this case the photographs were reduced by (*b*) from 3·6 inch to 2 inch.

The best method of obtaining the necessary line work of the final map is to reduce the strip to scale without previous inking in, which is done subsequently on the completed mosaic, especially when the detail on the reductions is clear, using the original photo strips as used in the field.

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The mosaic was built up on stout mill boards mounted with drawing paper. To make the strips fit, it was found sufficient to use a length of paper, cut to the length of the distance between the extreme points of each strip, and reduced to fit through the camera. None of the photographs were free from distortion which resulted in big accumulated errors in azimuth. For instance, a strip of four photographs contained a straight line of railway parallel to the direction of flight—when correctly fitted by overlap, the railway line had changed direction by 8° at the fourth photograph. This would be caused by a constant lateral tilt of about 6° in the axis of the camera.

Before drawing can be commenced, suitable prints on drawing paper must be obtained either (*a*) by tracing the detail from the mosaic, or (*b*) by obtaining a negative on the 1½-inch scale of the inked up mosaic from which ferro-type prints on drawing paper are prepared.

Results and proposals for future work.—Camera required (i.) to have gyrostatic stabilization; (ii.) adapted to take 4″, 6″, 8″ lenses; (iii.) plates or films 8″ by 8″; (iv.) magazine capacity plates or films, rolls of 100; (v.) automatic changing, resetting and exposing with adjustable exposure interval.

Details for organization of field parties are suggested, and also for ground control section for laying out helios, etc., before flying, but it is stated that with improved instruments and training of airmen, it will probably be best to allot a given area to a pilot to photograph as he choses, without artificial ground control. The necessity of having specially trained airmen for the work was clearly shown, and machines specially designed for the work will be necessary or desirable. For making a 1-inch map a scale of 2·5″ to 3″ for the photographs is ample, provided the definition is perfect. With a 6″ lens at 12,000 feet a scale of 2·7 to one mile would be obtained. Each photograph 8″ by 8″ would cover nine square miles, and allowing an overlap of 33 per cent, the working area would be four square miles. For two standard sheets (540 square miles) 140 photographs in nine strips would be required; add 50 per cent. for gap filling, or 210 photographs in 12 strips. Original photographs on this scale would be suitable for topographical maps on all scales up to four inches to one mile.

The total number of points required for a sheet would be 100 (or one to three square miles).

Cost.—Cost of ground work for one-inch survey, average for three years' work is Rs. 9·1 or 12/- per square mile, by ordinary methods.

(*A.*) Probable cost of ground work by an aero-party using photographs would be Rs. 6·7 or 9/- per square mile.

(*B.*) Cost of compilation of mosaics Rs. 0·8 or 1/1 per square mile.

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Cost of Royal Air Force share of the work based on figures supplied by Royal Air Force for the Agra experiment :—(1) Movement of machines and *personnel*, hangar, etc., Rs. 1,370 (2) Ordinary—Pay of *personnel*, rations, normal oil and petrol, etc., Rs. 8,230 (3) Extra —Officers detention allowance, extra petrol and oil, photographic stores, Rs. 6,290.

Assuming 8″ by 8″ plates are used, that only items (1) and (3) are charged to survey, and (2) is borne by Royal Air Force, and that a large area is done of 10,000 square miles, the (*C.*) calculation shows the cost to be Rs. 3.9 or 5/3 per square mile of flying and taking the photographs. If the total cost of the Royal Air Force is taken into account, then the cost rate would be more than doubled.

		s.	d.
Total cost rate is given as :	(*A.*) Ground work ...	9	0
	(*B.*) Compilation ...	1	1
	(*C.*) Photography ...	5	3

i.e. 15/4 per square mile, against 12/- per square mile by ordinary methods. The cost of triangulation and traversing has been omitted, as the difference would be at the most 1/- per square mile in favour of aero work.

The summing up is given thus :—It would appear that there is nothing to be gained by adopting the air method for normal one-inch Surveys in the plains of India. For larger scales, however, as two inch and four inch, especially the latter, the new method should eventually prove superior in every way.

City Survey.—The Lohamandi ward of Agra City was selected for the experiment. A 20″ lens was used flying at 3,000 feet, giving a scale of 1/1800.

A preliminary mosaic was prepared, and used by the party which carried out the triangulation on the roof tops. An area of 50 acres was covered, with five stations and thirty points. Thus the City of Agra containing 1,600 acres would require about 110 stations, and 600 or 700 points ; the photography would take about a week, and two triangulators would take say two months.

Errors in the photographs.—Assuming that the lenses cause no perceptible errors in the area of the plate, there remain three factors ; (1) Tilt of camera axis ; (2) Distortion due to focal plane shutter ; (3) Displacement due to heights of buildings and variations of ground level.

If the elements of tilt are known, absolute correction may be made, otherwise in large scale work with the complication of high buildings, it is stated to be impossible to correct.

(ii.) If the velocity of the focal plane shutter is 40 inches per second, and width of plate four inches, the shutter takes 1/10 second to cross the plate. The plane at 80 miles per hour moves 12 feet

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in this time, which is serious on a 1/1800 scale. Methods are discussed for overcoming this difficulty.

(iii.) The displacement of house-tops on a large scale is very apparent with reference to the ground. Practically speaking, a stabilized camera is essential; 48″ lenses at 6,000 feet give half the error of 24″ at 3,000 feet, hence are recommended. (Why not fly at the highest possible, say 15,000 feet, and enlarge up?)

Assuming there is no tilt, it is easy to find the position of the point vertically below the camera and hence to calculate the error. After describing the method used in preparing the photographs to fit the fixed points, correcting for heights of houses, the probable errors are estimated to be two to three feet, incidental to the mosaic. Further errors may occur in inking up the photographs on the ground. The various errors to which the air survey method is liable set a limit to the scale of the survey. It is suggested that 1/1000 is rather optimistic. This scale probably meets all requirements for Indian cities, in fact, for the majority of the uses to which a town survey is put, a smaller scale should suffice. The tilting board used with the enlarging lantern had unsatisfactory movements; hence fine adjustments could not be made.

The experiment was thus only partially completed. The results merely show that triangulation will be a sufficient and a rapid process compared with the traversing used in ordinary methods.

When a stabilizing camera is available, one must ascertain (*a*) the nature and amount of errors to which the mosaic will be liable; (*b*) the extent of ground work necessary to interpret the photographs and best method of carrying it out; (*c*) cost.

Methods for carrying out the above are then discussed. The approximate forecast for the cost rate per acre of all operations up to and including fair mapping, is given as 12/- per acre for the survey party, and the cost of photography by the Royal Air Force is given as a small fraction of 1/- per acre, totalling well under 15/- per acre.

In Chapter IV., Captain Salmond discusses the best type of plane to use and suggests one similar to the Pusher of the F.E. 2c type if water cooling difficulties can be overcome; otherwise he advises certain alterations in the Bristol Fighter if that plane is the only one available. He recommends an improved aneroid to fulfil certain conditions, also a statoscope to assist the pilot to maintain one level. Bomb sights are advised. Cameras, their mounting and their special fittings are discussed.

For ground control, he states that some form of controlling the direction and width apart of the strips when flying is absolutely necessary, though he is inclined to think helios are not satisfactory, and similarly doubts whether smoke flares would be cheap enough or satisfactory. He suggests other methods.

He advises flying at a greater altitude than 3,000 feet for city work.

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For future work of this kind either machines, instruments, ground control, etc., must be so improved as to eliminate the personal factor in pilots and observers, and so obtain uniform results of a high standard of perfection, or all pilots and observers must have specialized in this class of work, which differs very considerably from Active Service work.

As regards cost, Captain Salmond explains the difficulties under which the experiment was made, and lack of proper equipment making a true estimate impossible. He suggests however :—

	Open country work 3 inches to 1 mile.	City work.
Actual cost of present survey per square mile	26·9 Rs.	340 to 450 Rs.
Estimated cost under ideal conditions	9·5 Rs.	206 Rs.

He gives figures showing how he estimates above, thus :—

	Rs.	a.	p.
Cost of moving *personnel* and stores by train (1,000 miles), say	4,000	0	0
Erecting six temporary hangars or transporting R.A.F. tents, say	625	0	0
Incidental landing ground expenses	100	0	0
Officers T.A. (six Observers and one Photo Officer) ...	600	0	0
Officers' extra pay (Detention allowance), 12 Pilots and Observers and one Photo Officer for eight days	520	0	0
Petrol for photography, 28 hours at 13 galls. per hour ...	773	8	0
Oil ,, ,, ,, ,, ,, 0·7 galls. per hour ...	44	0	0
Petrol for journey to and from site (aeroplanes), 114 hours at 13 galls. per hour	3,148	0	0
Oil for journey to and from site, 0·7 galls. per hour ...	199	8	0
Petrol and oil for journey to and from site, one light tender and one motor cycle and side car	368	0	0
Petrol and oil for above for daily work at site (over and above normal), say 90–100 galls.	220	0	0
Depreciation, say	300	0	0
Photo-stores—cost proportional to that of 20 8" by 8" films per strip (28 strips)	1,400	0	0
Total cost for an area of 1,080 sq. miles at 1,000 miles from headquarters	12,298	0	0

Cost if carried out at headquarters of Squadron, Rs. 3·7 per square mile.
Rs. 1.4 per sq. mile for 1st 250 miles from headquarters.
Rs. 2.1 ,, ,, ,, every succeeding 250 miles above this.

To the above, must be added cost of "Post pointing," pasting down strips of photographs, reduction to scale, preparing the mosaic, inking it up, field work for helio lines, etc.

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Captain Salmond states that it is greatly to be regretted that the experiment at Agra had to be carried out under the conditions he described, since the conclusions to be drawn from it are of necessity vague and may be misleading. He concludes that :—

(1). Since so small a percentage of the air photograph is used on the 1″ map, it seems probable that Air Survey cannot compete with existing methods for this small scale over open and easily traversed country ; but probably could compete over thickly wooded country or flat country broken by ravines, difficult to plane table. He points out its value for Indian and Burma forests, or for revenue crop survey, or measuring winding streams, etc.

This conclusion confirms very much the Damascus experiment shortly described in the *Geographical Journal*, September, 1920. It might be definitely stated that for 6″ to 2″ maps the air photograph method should under most circumstances be cheaper than ordinary methods in the plains, even now. Had time permitted for one pilot and observer, specially trained, to do the work instead of using a flight of four, much better and cheaper results would have been obtained. At Damascus one pilot did an area of nearly 200 square miles in one flight, with no ground control, though he knew the area very well ; a second flight by the same pilot filled in the gaps. Though the results were not perfect, due to insufficient special training, lack of the proper cameras, instruments, etc., and a Bristol Fighter being used, the cost per square mile was less than the figure given above, and the indication was distinctly that with very little more experience and with the required instruments (c.f. stabilizing camera, etc.) very practical and cheap results could be obtained for a 6-inch map on flat country.

The report does not emphasize the fact that a photograph, if good, can be enlarged up to ten times, while retaining sufficient accuracy ; a map cannot. Hence a photograph taken at 13,000 feet giving a 2·6″ to the mile scale can be enlarged to 12″ or even to 25″; the cost for ground-work with the air survey method should be almost the same for a 6″ as for a 1″ map, whereas by ordinary methods this item is considerably greater for the larger scales. Hence it may be said that by air survey a 6″ map can be obtained at almost the same cost as a 1″ map that the cost of a 1″ map by air or ordinary methods is about the same. Smaller scales than 1″ will cost more by air survey than by ordinary methods, but contain much more information.

For City surveys it should not be necessary to fly as low as 3,000 feet. The cost varies inversely as the square of the height flown. Thus flying at 10,000 feet covers four times the area of flying at 5,000 feet. Using a 48″ lens at say 13,000 feet or even higher, one can enlarge up to the required scale.

The difficulty of the heights of houses can be got over by multiply-

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ing the number of photographs and using only the centres of the negatives.

Both Major Lewis and Captain Salmond suggest experiments with the stereo-autograph for overcoming the difficulties of uneven ground.

The method of making the map from photographs without re-drawing, but merely touching up the resultant mosaic to emphasize essentials and retaining all the detail of the photograph, is not mentioned; if the Indian Survey could also experiment on this it would be interesting to see what benefits could be obtained and what reduction in costs.

The experiments were obviously carried out under difficulties, and without proper equipment, but are most useful in showing that if Survey departments will spend small sums on improving equipment, and in practising the method, the results will eventually be very valuable and cheap for most of the scales above one inch. Without further practical experiment in suitable countries, little progress can be expected.

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PROFESSIONAL NOTES.

THE "SMALL HOLDINGS" SCHEME AT SUTTON BRIDGE.

THE Ministry of Agriculture and Fisheries commenced in 1920 on the development of an extensive estate at Sutton Bridge, near Wisbech, on the borders of the Wash, the intention being to provide "Small Holdings" for the settlement of ex-Service men on the land. There is much of interest in the construction of the cottages and farm buildings which is now proceeding, and the following notes are the outcome of a visit arranged by the Ministry.

Each "holding" consists of a parlour-type cottage, farm buildings, and from 5 to 30 acres. The estate is quite flat and there are no water supply or drainage arrangements. The cottages are mainly in pairs, and are distributed at varying intervals, depending on the size of the holdings; there are a few single cottages. The planning of the cottages is excellent, following much on the types recommended by the Ministry of Health.

All cottages have 11-in. cavity walls. The bulk are brick-built, with Fletton bricks from the neighbouring Peterborough district. Some are of the cast *in situ* concrete type. The roofs are etheri tiled, in various varieties of tiles, or thatched. Each has a shallow well and pump, an underground storage tank for 1,500 gallons of rainwater, surface drainage disposal arrangements, and an earth closet. The cost has not been found to vary greatly for the different types of construction, though brick is cheaper than concrete.

The work is being carried out by direct administration. The costs of the first cottages completed were 1s. 4d. per foot cube for a pair, and 1s. 6½d. for a single cottage, 7d. for the farm buildings. The latter are mainly simple in type, and vary according to the nature of the crops to be grown on the land. Costs are now showing a distinct tendency to fall. The figures given above include all overhead charges on the site and an allowance for depreciation of plant.

The following are the features likely to be of chief interest to R.E. officers.

Walling.—The 11-in. brick walls have a continuous cavity, which is ventilated by open external vertical joints about 6 ft. apart horizontally under the eaves and just over the damp course. A similar arrangement is made with concerte walls. Some of the brick and all the concrete cottages are rendered outside with a whitewash consisting of one cement, one sand and four lime, which has been very satisfactory. The lower 3 ft. is usually tarred. Pointing of brick walls has been generally dispensed with, the joints being roughly

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finished flush. This saves a little cost, and is claimed to be quite effective. Internal walls are mainly 4½ in., plastered two coats, the second coat finished with a wood float to a rough surface to obviate sweating.

Roofs.—Various forms of tiles are used. Pantiles when used are bedded in cement and laid on battens. The most interesting feature of the roofing is the revival of thatching. "Norfolk reed" thatching is still a local industry, and the family of the thatcher employed has followed this trade since the 13th century. While little cheaper than tiles, thatching gives an excellent roof of delightful appearance. The reeds are dark in colour and therefore never have the raw appearance of a new straw-thatched roof. Owing to the big overhang of the eaves, no eaves gutters are fixed; hence the thatched roofs cannot be used as catchments for rainwater. (Where the cottages are thatched the farm buildings are tiled and used to catch the rainwater). A pair of cottages can be thatched completely in 10 days. The slope of the roof is about 50 degrees. Some advantages of thatch are that owing to the ease with which dormer and semi-dormer windows can be formed, the upper windows can be of this type, and there is a saving of a foot or two in the height of the walls; the roof timbers can be of lighter scantling and the battens 12in. apart. With pantiled roofs, the barge board is usually carried up flush with the upper surface of the tiles and a fillet nailed to it over the verge tiles. This helps to prevent wind damage. Half round asbestos cement eaves gutters have been used, and are satisfactory and slightly cheaper than cast iron. In some of the farm buildings solid reinforced cement eaves gutters have been cast *in situ*; these are satisfactory and not expensive if made in quantity as the shuttering can be re-used. Elm fascia boards and soffit linings are used with tiled roofs, the elm coming off the estate. Elm has also been used for weather boarding of gables of farm buildings, and of some cottages.

Floors.—Ground floors are "solid wood" laid on a coating of tar on the concrete seal. Porous or breeze bricks are bedded in the concrete to take the nails, instead of the usual wood fillets. The floors are allowed to become perfectly dry before linoleum or other covering is placed on them, and the Ministry have no fear of dry-rot. Upper floors are constructed as follows:—⅝ in. boarding is laid on the joists, then a layer of felt, and then again ⅝ in. boarding, nailed through to the joists. Both layers of boarding run the same way, but the longitudinal joints are broken. There is no ceiling; the (creosoted) joists are exposed and the underside of the boarding finished white with "Ceilingite." These floors are very fairly sound-proof, and the absence of ceiling gives a little extra height to the rooms (which are 8ft. 3in. floor to floor). An advantage is that the upper layer of boarding need not be finally laid until the plastering of the upper room is completed, and can thus be kept clean from plaster. All

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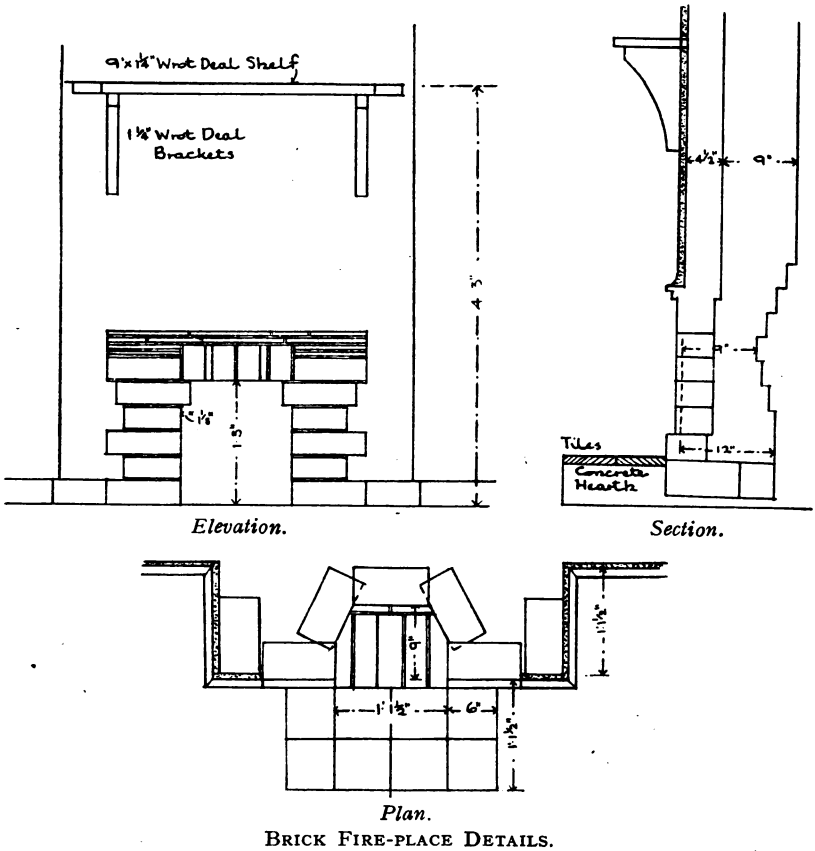
boarding is butt-jointed. Ceilings of upper rooms are of the usual lath and plaster type, finished with a wooden float.

Woodwork.—All exposed woodwork is creosoted. This is cheaper than the patent preservatives (1s. 6d. per gallon against about 2s. 3d.) and far cheaper than paint. The appearance is good; if waxed by the tenant, the finish should be lasting. Doors are all of a simple ledged and braced type. Windows are all wooden casements. A size has been standardized, and windows are therefore one, two, or three-light as required. In larder windows one or more panes are replaced by perforated zinc.

Fireplaces, etc.—The living rooms have the ordinary pattern of small cooking range. All the other fireplaces are of the extremely simple brick pattern shown in the figure. These are found most satisfactory; they are easy to light, will burn anything, heat the room very well, are of good appearance, and easy to clean.



Elevation. *Section.*

Plan.

BRICK FIRE-PLACE DETAILS.

A good hand-made sand faced brick is preferable for the facings. The back sides and hearth to be built in fire-clay bricks. Height of opening should vary with height of chimney. In 1st floor, bedrooms with low stacks should not exceed 1 ft. 6 ins., but on ground floor may go to 1 ft. 9 ins. or 2 ft. Cement pointing should be avoided as the heat tends to crack and loosen it. Lime mortar has been found best with plain flush joint. Back hearths may be raised or not as desired. If raised, height of opening should be taken from top of hearth.

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Water Supply and Fittings.—The necessity for strict economy in water, in a country where no water supply arrangements exist, and the annual rainfall is slight, has led the Ministry to omit the laying-on of water entirely. All has to be carried either from the pump which delivers from the well, or from the rainwater tank. The latter will, it is hoped, provide a reserve supply. In some pairs of cottages one side of the whole roof has been allotted, for catchment purposes, to one house, and the other to the other. It is questionable whether this is an entirely satisfactory arrangement, as one slope of the roof (the south or west) may catch much more water than the other, and after an abnormally dry winter the difference in the contents of the storage tanks on some pairs of cottages is marked. The sinks are fixed on iron cantilevers. They discharge through an untrapped outlet into a sealed gulley connected with the surface drainage. The outlet has a hinged flap at its end, to prevent the passage of vermin and draughts. Baths are fitted either in the sculleries or in small rooms with the coppers. The type usually adopted is a fireclay bath, 4 ft. 4-in. by 2 ft. internal. These are a little more expensive than cast iron baths, but are clean, of good appearance, and excellent for rinsing clothes. A smaller size, 4ft. 2in. internal, is to be tried. All baths are fitted with a double hinged flap, by which they are covered when not in use. This is useful on washing day, and helps to keep the heat in when the bath is filled. The method adopted usually is to put first a kettle of hot water into the bath and close it up; at the same time light the fire under the copper. By the time the water is heated the bath itself is warmed.

Work is proceeding on the scheme rapidly and without friction. The costs are low and the quality of the work unquestionably high. These results are being obtained by the Ministry of Agriculture by its admirable "team-work," under the general direction of Sir Laurence Weaver, K.B.E., Director-General of Works and Lands, and the immediate superintendence of the chief architect to the Ministry, Major H. P. G. Moule, D.S.O., M.C.

NOTES ON SOME CONSTRUCTION METHODS.

A SYSTEM of concrete house construction particularly suitable for operation by semi-skilled men has been adopted by Messrs. Sir Robert MacAlpine and Sons in the extensive housing scheme at Hayes, Middlesex, and is favourably reported on. This is known as the C.C.C. system and has been introduced by the Composite Concrete Construction Coy. of 51, Pall Mall, S.W.1., from whom an explanatory pamphlet can be obtained.

As compared with brick construction when bricks and bricklayers are available, there appears to be little, if any, saving in expense in

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this system ; but as the same drawings can be used for buildings whether of brick or on this system, it may well prove a suitable alternative to brick construction, particularly where the employment of semi-skilled ex-Service men is resorted to, or there is difficulty in obtaining bricklayers.

In essentials, the system consists in the construction of an outer and inner skin of breeze concrete slabs, built dry and kept apart by light wall-ties, the cavity being grouted with semi-liquid ballast concrete as the work proceeds. It is claimed, and supported by tests, that complete weather proofness and absence of condensation is obtained. The slabs are hand made, 1 to 4 for the outer walls and 1 to 6 for partitions ; kept in moulds for 48 hours and seasoned for 14–21 days. The ballast concrete is 1 to 8. A " band-course " of ballast concrete the full thickness of the wall is run on the upper floor level and again at roof plate level ; this serves to correct any irregularities in the height of the wall and to provide a bearing for joists. This course alone requires shuttering. The wall-ties are light hoop-iron, stove enamelled, and are not relied upon for strength to hold the wall together ; it is found that the ballast concrete core keys into the slabs so firmly that the wall is practically monolithic. Flues are usually built in brick. The fixing of down-pipes, etc., is much simplified by the fact that the outer skin of the wall being breeze concrete will take nails. The damp course is slate, the cement plinth being tarred.

The experience of the same firm of contractors with the well-known form of construction which consists of steel framework with a plastered metal-lathing external skin, and a light lining, is worthy of note.

Houses built on this system have been found considerably more expensive, in the locality, than those of brick or on the " C.C.C. " system. Their planning must necessarily be the simplest possible, and their appearance, beside brick houses, is poor.

Large numbers of skilled plasterers are required, if many houses on this system are to be built. Plasterers are the rarest of skilled tradesmen. The Cement Gun has been used for the external plastering, and while the appearance of work so done is a little uneven, the penetration of the plaster and consequent covering and preservation of the inside of the metal lathing are better than with ordinary hand-plastering.

It is most important that a good covering of concrete over the steelwork, including the framing, externally should be obtained. This is required not only to protect the steel from corrosion, but also to protect it from temperature changes, which by causing expansion and contraction in the steel may cause cracking in the plaster.

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BULLETIN DE RENSEIGNEMENTS DU GÉNIE.

In a notice on the re-appearance of the *Revue du Génie Militaire*, published in the *R.E. Journal* in April last, mention was made of 12 numbers of the *Bulletin de Renseignements du Génie* which had been published under the direction of the *Inspection Générale des Travaux et Organisations aux Armées*. By the courtesy of the *Section Technique du Génie* of the *Ministère de la Guerre* the R.E. Institute is now in possession of a complete *series* of the *Bulletin*, which is being bound and will be placed in the Corps Library at the Horse Guards. The period covered by this publication extends from 30th, Sept. 1917 to July, 1919, and many of the articles contained in it are of the greatest technical and historical value.

F.E.G.S.

CORRESPONDENCE.

THE TIBET MISSION OF 1903-04.

To the Editor, R.E. JOURNAL.

DEAR SIR,

I am obliged to your correspondent, Mr. Hinks, for corroborating the essence of my letter in *R.E. Journal* of February.

Major Morshead's phrase therein alluded to led me to conceive that Major-General Sir Ronald Macdonald's services in Tibet might be forgotten, and so my motive in writing was to invite the attention of the readers of the *R.E. Journal* to the distinguished service of a brother officer of a former generation.

I had only my memory to rely on; but now Mr. Hinks produces Blue Book evidence of the validity of my statement. True, Mr. Hinks finds me guilty of not being "quite accurate," and would thus discredit me with my brother officers as a true recorder of facts were it not that he puts the matter beyond possibility of doubt by quoting authoratitive evidence that "preponderance for the present must be given to military considerations, and General Macdonald has been authorized to take all measures necessary to secure safety of Mission."

To the best of my recollection the actual instructions given to General Macdonald, at this period, are given in the Blue Book, and if I am right, those that are interested can see them for themselves. Doubtless their inclusion would have made Mr. Hinks' letter too long.

It is immaterial to my purpose whether the force commanded by General Macdonald was, technically, an expedition or an escort. I merely copied the words "military" and "expedition" from Major Morshead.

Yours very truly,

J. A. FERRIER, *Maj.-Gen.*, (late R.E.).

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REVIEWS.

THE GREAT WAR IN 1914.

By LT.-COL. F. R. SEDGWICK, C.M.G., D.S.O., R.A. (Forster Groom and Co., 16, Charing Cross, S.W.1.)

The author avoids all tactical details and deals only with the strategy of 1914. The initial concentration and subsequent moves in the Eastern and Balkan as well as in the Western theatre of war are concisely laid down and shown on several clear and well arranged maps. There are certain inaccuracies, probably due to insufficient material being as yet available, but the author's comments and observations are full and interesting and if not altogether in agreement with our own opinions will give plenty of food for discussion and thought.

E.H.K.

A MEMOIR OF LT.-COL. EDWARD ANTHONY STEEL, D.S.O., R.H.A. AND R.F.A., 1880–1919.

Compiled by his father, COLONEL J. P. STEEL, late Royal Engineers. (Simpkin, Marshall, Hamilton, Kent & Co. Price 6s.).

This brilliant young Officer died at Omsk in Siberia on 12th September, 1919, from influenza resulting from a wound in the lung received in France three years earlier. He lies in the Cossack cemetery at Omsk, and his father, considering the remoteness of his grave and in the endeavour to keep the memory of this gallant soldier green, substitutes for marble or brass a simple record of his short but eventful life. The story is told mostly in letters, and is one of strenuous work and sport, from his school days at Dover College to his death while training Russian artillery with the British Military Mission. As a Subaltern in L Battery in India, with many football and athletic successes, on the Anglo-Belgian Boundary Commission, and in the Great War, it is a tale of keen work and keen play, qualities always associated with the best type of British officer.

F.E.G.S.

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NOTICES OF MAGAZINES.

MILITÄR WOCHENBLATT.

No. 35.—*Why Germany sent Lenin to Russia.*—Ludendorff contributes an article on this subject, and quotes Bismarck to the effect that, in a war for national existence, weapons must be chosen primarily for their immediate efficacy; their after effects must be of only secondary importance. With this principle in mind he agreed to the proposition, put forward by the Chancellor, to send Lenin and his colleagues from Switzerland through Germany to Sweden. According to Ludendorff, the Tzar had shown himself inclined to make peace, so his allies, led by the British Ambassador, brought about a revolution, with a view to putting in power a party that would be willing to go on with the war. This revolution certainly weakened the Russian army, but it did not destroy it, and Germany's forces were too weak to effect much at this time. On the other hand American troops would soon be arriving in France, and if an attack in the West was to be successful, it would have to be made soon. The Chancellor hoped that the dispatch of Lenin would lead to a more rapid development of the Revolution and a strengthening of the peace parties. G.H.Q., on the other hand, was chiefly concerned with the weakening of the Russian armies, to the point of destruction. Ludendorff, who up to then had never heard of Lenin, did not know who advised the Chancellor, but supposed it to be one of the Social-democratic party. This supposition has since been shown to be correct. G.H.Q., finding a weapon ready to hand, used it, but their part in its preparation was confined to arranging the journey. German attacks in 1917 scattered the Russian armies, but it was not until Lenin and Trotski came into power that peace negotiations began. From a military point of view the action of the government was justified. Whether its political consequences were foreseen is another question.

A German view of French and English literature on the War is given by Gen. von Kuhl. He says that all French and English critics reveal how near Germany often was to a military victory, quite apart from any success attributable to the U-boats. Among French writers, Buat, Mangin, and Pierrefeu get attention, and among the English, Capt. Wright, though described as "highly dramatic," is taken seriously.

Protection against Moneylenders.—The poverty to which German officers have been reduced has made them an easy prey to moneylenders; a society has been formed for their protection, and all officers are recommended to consult it before signing any agreement.

Obituary notices.—(18. 2. 21) Colonel-General von Boehn; he commanded an Army group. (13. 2. 21) Major-General Karl von Kraewel. As colonel he commanded the 159th Infantry Regiment and achieved

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distinction when he took command of the Kraewel Brigade on the 8th September, 1914, when he put up a very good fight at Montreuil-aux-Lions against the British.

No. 36.—*French coloured troops.*—The *M.W.B.* is much concerned with the efforts which France is making to organize the great resources of man-power which her colonies give her. Before the war she had only 60,000 coloured troops, but by the end of it no less than 545,000 had been raised. Naturally training and administrative services could hardly keep pace with such a rapid expansion, but great efforts are now being made to overcome the numerous difficulties met with, in raising and training the various native troops from French colonies. For the year 1921 it is hoped that Madagascar and Equatorial Africa will raise 60,000, which, with 100,000 from North Africa and 40,000 from Indo-China, will make up 200,000. Provision of officers and N.C.Os. for such large numbers is one of the great difficulties. The *M.W.B.* concludes with the usual protest against the employment of coloured troops in the occupied districts, but admits that many of the complaints against them are exaggerated.

The Council system in the Austrian army.—When the old Austrian army was " stabbed in the back " (*i.e.*, on being defeated in the field broke to pieces through internal action) a number of small units termed " People's defence force " were formed. These subsequently formed into battalions and were equipped from the old army's stores. They were ruled by " Soldier's Councils," who saw to it that officers of the kind they desired were elected. Military training or experience was not a necessary qualification ; political views were the important factor. Naturally all kinds of administrative " mistakes " occurred, but the Councils were so strong politically that the Government was continually obliged to give way to them. In order to strengthen their position still more and to estrange the real officers from their men, the Councils decided that all training was to be done by civilians ! The scandals, which arose in connection with the " People's defence force," became so bad that the less radical parts of parliament decided to work for its reorganization on a new basis ; little, however, has been achieved in this direction. The Minister for Defence, Dr. Deutsch, has drawn up rules for the Soldiers' Councils, according to which their powers extend to the following matters—clothing, rations, accommodation, training, complaints, leave, and discipline. They have also to watch over the actual issue of pay, clothing and rations ; a fairly comprehensive list !

No. 37.—*The Council system in the Austrian army (continued).*—Although the powers of the Councils are of wide extent, their exact limits have not been defined and it is from this lack of definition that difficulties chiefly arise. The fact that the members of the Councils are not subject to military discipline and none of their actions liable to restraint, does not make the situation any better. The establishment laid down for the strength of the Councils is 1117 ; this in an army where the total number of serving soldiers is under 20,000 ! Of these more than 100 are struck off all duties, and devote themselves entirely to the interests of their electors. The expenses of the Councils fall, of course, on Army votes and amount to the enormous total of 50 million kroner

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per annum. In addition to the 1117 men counsellors there are 61 Officer counsellors, instituted by the bourgeois party, to form a counter weight to the very "red" soldiers' councils; 52 of these are struck off all duties, and their cost must be added to the above-mentioned 50 millions. These officers' councils effect no object, as they have little political backing. The men's councils are closely affiliated to the unions formed by the lower grade employees in other state departments, and are really in closer touch with them than they are with the army they are supposed to represent. The more orderly elements in the ranks are beginning to tire of being pawns in the political game and there are signs of a more soldierlike feeling. These symptoms are very unwelcome to those who wish to maintain and widen the division between officers and men, and a system of classes of instruction for soldiers' councils has been started. It remains to be seen what the result of this struggle for power between the Army command and the extremists is going to be. The next step will probably be classes of instruction for officers in political and economic subjects.

L. CHENEVIX-TRENCH, *Major, R.E.*

REVUE MILITAIRE SUISSE.

No. 12.—*December*, 1920.

The Training of the Recruit and Physical Development.—The original article is contributed by Professor E. Hartmann, who is of opinion that the best means for ensuring the proper physical development of the recruit would be by making physical exercises a part of the general course of instruction of the youth of a nation, in the same way that the intellectual and the moral development of young people is now made to form part of the educational system in Switzerland. The subject is dealt with under five heads: (1) physical training in primary schools (from the age of 7 to 13); (2) physical training in secondary schools (from the age of 13 to 16); (3) physical training from the age of 16 to 20; (4) stricter examination of the recruit's physical condition; and (5) the posting of recruits to the several arms on the basis of their physical development. In Switzerland, gymnastic instruction must, at the present time, be provided under the provisions of a law of November, 1909, in public and private institutions for all students during the whole period of instruction given them. But apparently no system of inspection has yet been inaugurated to ensure that the Federal Law on the subject is being complied with.

Piecemeal Strategy.—Colonel Feyler deals, in the original article, with General Sarrail's campaign in Macedonia. As an introduction to the subject, he reviews very briefly Napoleon's campaigns of Austerlitz (1805), Jena (1806) and Friedland (1807), to provide a comparison with the conditions under which General Sarrail had to carry on from 1915 to 1918. During the three years, 1805–1807, the main feature of the military effort consisted in the concentration of forces on the part of France, in contrast with the strategy "des petits paquets" of the Allies opposed to her. Colonel Feyler indicates that when General

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Sarrail retreated on Salonica in 1915 the Germano-Bulgarian forces possessed an incontestable superiority, which should have enabled them to clinch matters by a march southwards, but political motives reduced these forces to inaction. The Allies resorted to a strategy "des petits paquets," and only after the elapse of three years reaped an advantage from the mistake made by the Germans in not following up General Sarrail. Colonel Feyler points out that there is no hard and fast rule which lays down that theoretical principles are never to be departed from. On the contrary, the teaching of history is that science is not everything, but that art often plays an important rôle in the decisions of a military commander, who can appreciate when it is wise to break from rules. For instance, the Russians were justified, in the circumstances that existed, in taking the risks which they took in 1914 in moving before their mobilization was complete. The Russian defeats at Tannenberg and the Masurian Lakes were not due to numerical inferiority, but to faulty leadership. Victory does not depend upon the maximum of concentration *possible*, but on the minimum of concentration *necessary*. As a general rule, a strategy "des petits paquets" is a mistake; it exposes the side which resorts to it to defeat, not only by an opponent who concentrates the whole of his forces, but also by one who appreciates what minimum of concentration will give him a superiority over his foe.

New Swiss Training Manual.—Colonel Foujallaz discusses, in the original article, the plan to be adopted for training troops for the battle. He points out that "standard attack formations" possess the disadvantage of creating preconceived ideas in relation to the general course of a battle, of giving, so to speak, a recipe strictly to be followed, leading to the belief that one's adversary will adopt that course which is expected of him. A training based on "standard formations" results in the adoption of faulty battle plans, which are too cramped to meet practical needs.

NOTES AND NEWS.—*France.*—In a contribution from a special correspondent is discussed the question of the forces which contribute to the prosperity of a nation. It is held that a nation lives by the external influences it is able to exert as well as by its internal activities and the trading within its borders. The prestige which Germany enjoyed throughout the world up to 1914 was due to the victories of her armies in 1866 and 1870. In defeating Germany in 1918, the Allies have destroyed pro-German influences. The course of events has proved the superiority of the French doctrines; and it is expected that in future a larger number of foreign military officers will study French military matters, and also that the demand for French instructors for foreign armies will increase. There are already in Paris 450 foreign officers, who are making a study of the French Army and its methods; in addition there are military attachés from 25 Armies, many of which are represented by two or more officers, *e.g.*, U.S.A. by 9, Roumania by 4, Great Britain, Italy, and Serbia by 3 each, etc.

W. A. J. O'MEARA.

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PROBLEM.

PROBLEM 24 (Solution).

A MAN has 121 francs and 70 half-crowns, reckoning 25 francs as equal to £1, find the number of ways in which the man can pay 1/3 of the money in his possession. What is the smallest number of coins with which he can make the payment?

1/3 of total sum = 453/5 shillings.

Let x be number of half-crowns, y number of francs, with which 1/3 of sum can be paid, then

$$\frac{5x}{2} + \frac{4y}{5} = \frac{453}{5},$$

That is $$25x + 8y = 906.$$

Now $x = 1$ $y = 3$ is a positive integral solution of $25x - 8y = 1$.

Hence $$x = 906 - 8M \quad y = 25M - 2718$$

is an integral solution of $25x + 8y = 906$.

For the solution to be positive as well as integral

$8M$ must be less than 906

and $25M$ must be greater than 2718.

Hence M must range from 109 to 113 inclusive.

Hence the only possible values of x and y are (34 . 7) (26 . 32) (18 . 57) (10 . 32) (2 . 107).

That is to say there are 5 ways, and the smallest number of coins is 41.

The following is the solution sent by Captain F. Buero, Royal (Spanish) Engineers :—

25 francs = £1 whence 1 franc = .8s.

The man has $.8 \times 121 + 2.5 \times 70 = 271.8s = 3$ times 90 . 6s.

The payment will be $.8 \times f + 2.5 \times s = 90.6$.

The two last figures of $2.5 \times s$, are : 2 . 5, 7 . 5, 5 . 0, or 0 . 0, whence the two last ones of $.8 \times f = 90.6 - 2.5 \times s$ will be 8 . 1, 3 . 1, 5 . 6, or 0 . 6.

As $.8 \times f$ is a multiple of .8, the last two digits will be 5 . 6.

Therefore $$.8 \times f = 10 \times n + 5.6$$

or $$f = \frac{10 \times n}{.8} + \frac{5.6}{.8} = \frac{100 \times n}{8} + 7 = \frac{4 \times 25 \times n}{4 \times 2} + 7 = \frac{25 \times n}{2} + 7.$$

f and $\frac{25 \times n}{2}$ must be integer numbers, and n an even one consequently.

Besides this, $$\frac{100 \times n}{8} = \frac{25 \times n}{2} = f - 7 = 121 - 7 = 114,$$

and $$n = \frac{2 \times 114}{25} = 9.12.$$

n	f	s	No. of Coins.
0	7	34	41
2	32	26	58
4	57	18	75
6	82	10	92
8	107	2	109

Therefore n must be an even number no greater than 10 ; it can be 0, 2, 4, 6, and 8, and we have the 5 following solutions.

The smallest number of coins is 41 . given by the first solution.

J. M. WADE, *Lt.-Col.*

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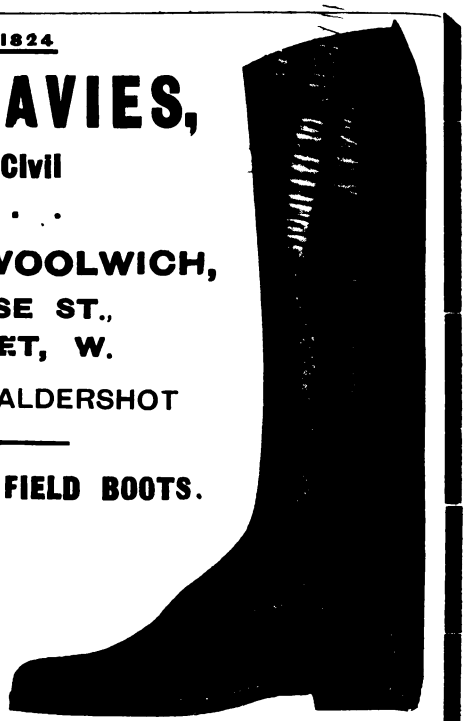

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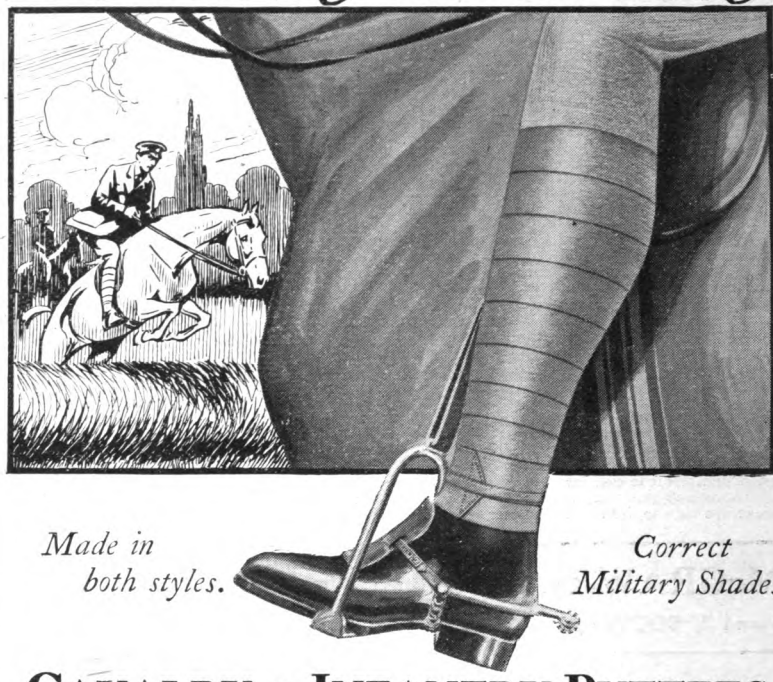

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THE Montgomerie Prize for the year 1920 has been awarded to Captain L. C CARUS-WILSON, M.C., R.C.S. (late R.E , for his article "Earth Current Telegraphy," which was published in the *R.E. Journal* in January 1920.

The unawarded Prize for 1919 has been specially awarded to Major H. T. MORSHEAD, D.S O., R.E., for his article "An Exploration in South East Tibet," which was published in the *R.E. Journal* for January 1921.

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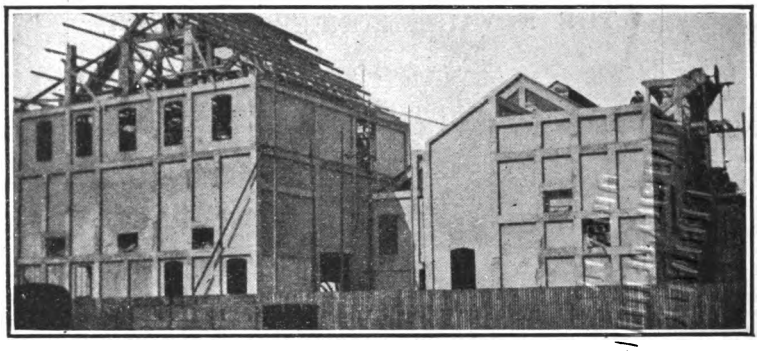

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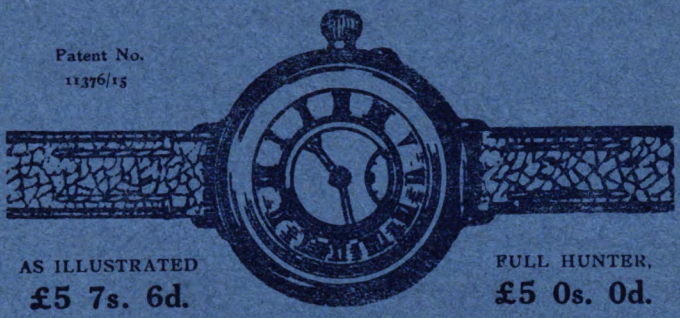

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